Niveau(x) d'enseignement: 7 Numéro EDUQ : 8270309
Centre d'intérêt: 59

Generic learning and the DAASAN approach / [ed. by] Subbanna Vadlamudy with Grant Brown... [et al.]. -- Montréal : Dawson College, 1976.
v, 110 p. : graph. ; 28 cm.

Errata inséré. Bibliographie: p. [9]-10.

Cote Dewey: 370.15'23/G326 Cote LC: LB/1062

Descripteur(s): *Apprentissage *Créativité *Méthode d'enseignement *Enseignement non directif *Biologie *Chimie *Mathématiques *Physique *Collégial (Niveau)

Identificateur(s) de nom: *DAASAN (Méthode)

Identificateur(s) de sujet: *Apprentissage générique *Pensée créatrice

---

Il importe d'aider les étudiants non seulement à mémoriser des connaissances mais aussi à apprendre à penser. Le document rend compte d'une expérience menée en ce sens. Elle a consisté à concevoir des cours de science de niveau collégial qui fassent appel à deux types de notions: des concepts à acquérir comme faits, c'est-à-dire de l'information factuelle (80% du contenu), et des concepts à acquérir par le biais de situations d'apprentissage générique (20% du contenu). On peut définir l'apprentissage générique comme un procédé de pensée créatrice qui repose sur l'organisation et la manipulation de connaissances déjà acquises.

Le document décrit et commente l'application d'une telle pédagogie, au cégep Dawson, à des cours de mathématiques, de chimie, de biologie, de statistiques et de physique. Dans le but de faciliter la mise en place de situations d'apprentissage générique, une méthode d'enseignement a été élaboré, la méthode DAASAN: "Directed activity to acquire specific abstractions in nature".

L'expérience démontre qu'il est possible de concevoir, au niveau collégial, une méthode pédagogique qui permette d'enseigner aux étudiants comment apprendre à penser. Dans l'ensemble, les étudiants ont accueilli très favorablement cette approche: 92% d'entre eux accepteraient de suivre à nouveau des cours où l'accent serait mis sur l'apprentissage générique. Il faut toutefois préciser que la mesure de l'efficacité d'une telle approche ne faisait pas l'objet de la recherche actuelle.

Type de document: r
Région(s) administrative(s): 063
Financement: Bénéficiaire - Collège Dawson
Organisme(s) source(s) - MEQ - DGEC
Programme(s) de subvention - PROSIP
Auteur de l'analyse: jr

E D U Q 8270309

GENERIC LEARNING AND THE DAASAN APPROACH

Is a half full glass
also half empty?

DAWSON COLLEGE
MONTREAL 1976

IS A HALF FULL GLASS ALSO HALF EMPTY?

What do we mean by half empty?

What is emptyness?

Room is empty. Space is empty: vacuum.

Is vacuum present in half empty glass?

Is air present in the glass?

What else is present in the glass?

When we open a perfume bottle how come we can smell it from a distance?

Does water smell?

Does water vaporise?

What happens to water in the glass if we leave it open for a few hours?

Water from rivers, lakes and oceans also vaporises. Is it disappearing into space?

Is rain and snow newly created water to replenish?

If water evaporates leaving behind the impurities and condenses back as rain, how come our lakes and rivers are always polluted?

Can we clean something without dirtying something else?

How long can your system survive without clean surroundings?

Suby

E D U Q 8270309

GENERIC LEARNING AND THE DAASAN APPROACH

Subbanna Vadlamudy

with

Grant Brown
Keith Fern
Jan Janmohamed
Eleanor Van Norman
Klaus Dichmann
Shastry Jandhyala
Gerry Portner
Sanford Witherell

CONTENTS

PREFACE	V
INTRODUCTION	1
DAASAN APPROACH	11
GENERIC LEARNING SITUATIONS:	18
- INTRODUCTION TO APPLIED MATHEMATICS (Grant Brown)	19
- GENERAL CHEMISTRY (Klaus Dichmann)	29
- GENERAL BIOLOGY I (Keith Fern)	48
- STATISTICS (Shastry Jandhyala)	52
- GENERAL CHEMISTRY (Jan Janmohamed)	57
- WAVES AND MODERN PHYSICS (Gerry Portner)	65
- GENERAL CHEMISTRY (Subbanna Vadlamudy)	80
- HUMAN BIOLOGY (Eleanor Van Norman)	87
- GENERAL BIOLOGY II (Sandford Witherell)	98
CONCLUSIONS AND LAST WORDS	104
APPENDIX	106

INTRODUCTION

The myth in Plato's Meno[1] about the latent power of the soul to remember truths it has already seen, corresponds to the mind's power to discern unchanging forms in the changing world it confronts; this seems to be more of a prophecy if one examines some of the issues debated in the contemporary education scene. In spite of the vast amount of knowledge that we have acquired since Plato's time, the battle between Sophists and Socrates[2] is still being fought by Behaviorists and Non-Behaviorists[3,4]. Such a battle is perhaps unnecessary; the question is not one of a choice between different slogans. As Plato[5] pointed out there are many aspects to reality; accordingly, there are many aspects to education. The various aspects of education rely upon one another. Any effort to make one aspect dominant or independent aims at shaping minds with a distorted sense of reality. Then the question is, where does one draw the line? The philosophical and pedagogical considerations that helped us answer this question are presented in the following sections.

PREFACE

Information explosion, scientific and technological achievements and rapidly changing social values have been the sense of reality of the past decade or so. This sense of reality in the field of education is forcing teachers to examine their assumptions about the aims of education, in the light of the available information about how learning takes place, and develop a workable approach to teaching. Our experimentation with the DAASAN Approach represents one such effort to attain the aims of education as we perceive.

Our concerns and considerations that have led us to propose the'DAASAN Approach', are presented along with some of the "Generic Learning" situations that we have experimented with in Biology, Chemistry, Mathematics and Physics courses. The name of the experimenter in each case is mentioned; the remaining part of the report is the work of Subbanna Vadlamudy.

Sincere appreciation is due to a number of persons who have been either directly or indirectly involved with the "Generic Learning" project.

Grateful acknowledgement is due to 'Direction Générale de l'Enseignement Collégial', Ministry of Education, Province of Quebec for a research grant awarded to us.

DAWSON COLLEGE
350 Selby St.
Montreal, H3Z 1W7

Subbanna Vadlamudy
For the Generic Teaching Group
September 1976

INTRODUCTION

The myth in Plato's Meno[1] about the latent power of the soul to remember truths it has already seen, corresponds to the mind's power to discern unchanging forms in the changing world it confronts; this seems to be more of a prophecy if one examines some of the issues debated in the contemporary education scene. In spite of the vast amount of knowledge that we have acquired since Plato's time, the battle between Sophists and Socrates[2] is still being fought by Behaviorists and Non-Behaviorists[3,4]. Such a battle is perhaps unnecessary; the question is not one of a choice between different slogans. As Plato[5] pointed out there are many aspects to reality; accordingly, there are many aspects to education. The various aspects of education rely upon one another. Any effort to make one aspect dominant or independent aims at shaping minds with a distorted sense of reality. Then the question is, where does one draw the line? The philosophical and pedagogical considerations that helped us answer this question are presented in the following sections.

PHILOSOPHICAL CONSIDERATIONS

The abiding value of Plato's educational philosphy is widely diffused in contemporary education. Some consider that arguing for Platonic values is old-fashioned. The fact that we still share Plato's vision of what education ideally ought to be, and still are thinking through his problem of how to bring the actual closer to the ideal, is a tribute to the ancient Greek philosophers. Thanks to the discoveries in science and technology, we now are in a better position than ever to deal with the process more imaginatively. However, the self-betterment is far from over.

In the contemporary world there is an attempt to bring together the vividness and romance that were part of the Greek view, the freedom and mechanistic reality as recognized in the period of Enlightenment and the concern to process as advocated by Dewey, Whitehead and other 20th century philosophers of education. Evidence for this can be found in the aim of education as defined by the International Commission on the Development of Education,[6] established by UNESCO, as being the physical, intellectual, emotional, and ethical integration of the individual into a complete man. Further, they suggest[7] that "basic education must be many sided and, while dispensing fundamental knowledge, aims at learning how to perceive and comprehend the world. It further must endeavour to instil a taste for self-learning; to arouse the desire to know, to question, while developing the faculties of observation and judgement and the critical spirit. Finally, it should try to awaken the feeling in an individual that he belongs to a community and that each person has a creative responsibility towards himself and others."

EDUCATIONAL OBJECTIVES

Following the system of ancient Greek philosophers, the educational objectives are classified into three major domains: Cognitive, Affective and Psychomotor. The cognitive domain is most central to current educational research mainly because: (1) cognitive objectives vary from simple recall of material learned to highly original and creative ways of combining and synthesizing new ideas and materials, (2) the largest portion of educational objectives fall into this domain and (3) tests and information are more easily scored and transmitted. The taxonomy of cognitive educational objectives as organized by Bloom and co-workers[8] contains six major classes: 1) knowledge, 2) comprehension, 3) application, 4) analysis, 5) synthesis 6) evaluation.

The educational objectives are hoped to gain meaning through two rather distinct processes[9]. One process is that of defining the objectives in behavioral terms and then determining the evidence which is relevant in judging whether students have or have not "achieved" the objectives. The second process is that of trying to place an objective within a large over-all scheme. Thus, educational objectives help focus the needed attention upon the analysis of an instructional procedure and its appropriateness in working towards the aims of education. The following example (used in a first year chemistry course) illustrates these points. Consider the objective "ability to write the equation that relates the state properties of an ideal gas" whose terminal behavioral objective is to elicit a response if correct is $PV = nRT$.

To enable the student to achieve this objective, one might tell the student (lecture method) that the relationship is $PV = nRT$, or

tell the student where in a text book the relationship can be found (behavioral method) and expect the student to memorize for recall when tested. For these purposes the process could be simplified by restating the objective as "knowledge of and ability to write the equation of state of an ideal gas; PV = nRT".

In the following method the student is given a chance to exercise his/her intuition and apply knowledge acquired in other subject (s) in arriving at the relationship PV = nRT. One could start by defining system, state of a system, and identifying state properties of a gaseous system. And, after acquainting the student with the fact that the study of a relationship between any two state properties is simplified by keeping others constant, the student is asked to consider the following situations:

(1) Keeping V, T constant, more and more gas was introduced into the vessel (Fig.1) while noting the pressure registered by the pressure gauge. The following are some observations:

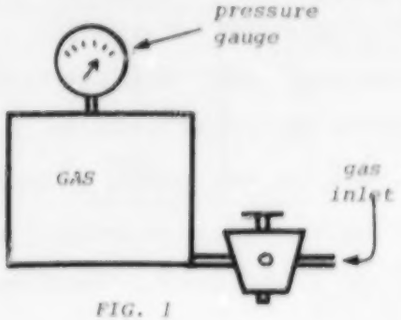


FIG. 1

Pressure (P)	Amount of Gas (n)
0	0.0 moles
3 units	0.1 moles
6 units	0.2 moles
9 units	0.3 moles
18 units	0.6 moles

State the relationship between P and n when V and T are constant.

$P \propto n$ or $P = \text{constant} \times n$

(2) Keeping n and T constant the pressure exerted by the gas when it occupies different volumes is measured using a vessel shown in Fig.2.

By adjusting the piston, the gas is allowed to occupy the available volume underneath it. The results are shown in the following table.

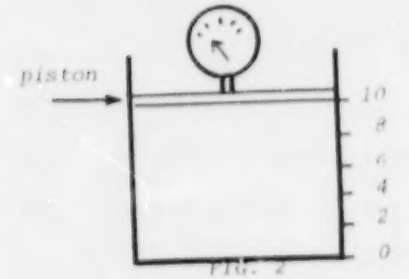


FIG. 2

Pressure (P)	Volume (V)
2.4 units	10 l
3.0 units	8 l
4.0 units	6 l
6.0 units	4 l

State the relationship between P and V when n and T are constant.

$P \propto \frac{1}{V}$ or $PV = \text{constant}$

(3) By keeping the amount of gas and volume occupied by it constant, the relationship between pressure and temperature of the gas is studied in a vessel shown in Figure 3. The results are shown in the following table:

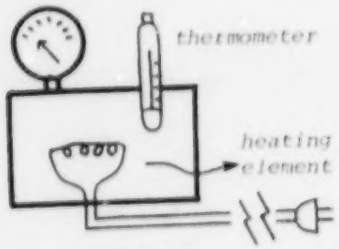


FIG. 3

Pressure (P)	Temperature (T)
0.2 units	300 K
0.4 units	600 K
0.6 units	900 K
1.0 unit	1500 K

State the relationship between P and T when n and V are constant.

$P \propto T$ or $P = \text{Constant} \times T$

Combine the above three relationships into one relationship between P, V, T and n denoting the constant by R called gas constant

$P \propto \frac{nT}{V}$ or $P = \frac{RnT}{V}$ (on rearranging we get $PV = nRT$)

In the above method, by asking the student to manipulate the given

information, higher levels of cognition Viz. application, analysis and synthesis are brought into play while acquiring the knowledge. Further, this method might lead to all sorts of unexpected questions - some related to self-confidence, some asking for help and yet others enquiring about related concepts. In an actual learning situation questions like, "Is this correct? How is the amount of gas measured in the set up shown in Figure 1? What thermometer is used to measure a temperature of 1500 K in Figure 3?" were asked by the students. Some of these questions, unexpected as they may be, brought out the inadequacies of the hypothetical experimental set up, and led to significant learning, thinking and creativity. This is not to say that behavioral and lecture method cannot and do not deal with higher levels of cognitive behavior. They can. But the methodology has to be different from the one mentioned earlier.

CREATIVITY, THINKING AND GENERIC LEARNING

Learning is essentially a creative activity involving exploring, observing, classifying, questioning, generalizing, elaborating, amplifying, etc. All these activities involve thinking. Recognized authorities in education profess that the development and widespread application of the thinking process should be the central and pervasive goal of education. John Dewey[10], Hilda Taba[11], Jerome Bruner[12], Richard Suchman[13], Richard Crutchfield[14], Benjamin Bloom[8], and others have taken constructive action to promote this goal.

It does seem possible to teach children to think creatively[15,16]. Creativity has been found to have little correlation with scores on I.Q. tests. Training in thinking skills produced significant gains in children of average and below average I.Q. as well as for higher I.Q. children.[17]

Children trained in thinking skills excel in being sensitive to puzzling factors, in asking relevant information seeking questions, in generating ideas of high quality, in seeing problems in new ways, in planning a systematic attack on problems, in evaluating ideas and in achieving actual solutions to problems.

In education, the post Sputnik era saw a surge of interest in developing creativity in children. New programs and curricula were developed for implementation in elementary and secondary schools. Introduction to physical sciences, Physical Science Study Committee, Chem Study program, K-12 Curriculum, etc., are some examples. The rationale for the focus on the development of the child's thinking skills was based on the following premises:

A. The key "constant" in today's world is change.

B. Since numerous problems of tomorrow's world defy prediction, children must be equipped with skills of "changeability".

C. Skills of "changeability" would best be developed if children were provided with ample opportunities to utilize their thinking process in acquiring knowledge.

Emphasis on creativity training is evident mostly in pre-school, elementary and secondary education. Perhaps this could be the result of psychopedagogic research on logical thinking from childhood to adulthood[18,19]. Specialists in child development generally agree in distinguishing between several stages of mental development. Causal relations are established up to the age of 2; between the ages of 2 and 7, symbolic function develops. At the age of 7 or 8 mastering two-way reversible operations occurs. Mastery of reasoning based on hypothesis appears towards 11. The mind becomes truly

experimental near the age of 14 or 15. Young adults, who already belong to an organized society which channels them, applies brakes or arouses them to rebellion were found to be less creative. The implications for teaching young adults are clear. They also should be given sufficient opportunities to exercise their creative abilities. This is further supported by the present psychopedagogic view that, influences modify behavior and nothing is fixed until death.

Several methods used in creative training can be found in the literature. Brain storming[20], synectics[21], inquiry method, discovery method, inductive and deductive approaches, lateral thinking[22], directed discovery, concept learning[23], and generic methods were suggested. Brainstorming and synectics were developed by psychologists in the business world and use group process to arrive at a creative idea. The Socratic method i.e. the inquiry method, took a new meaning with the advent of the electronic age[24]. Considerations like "a half-full glass is also half-empty", might bring out interesting aspects of a problem in lateral thinking. Inductive and deductive approaches are used in "discovery" and "directed" discovery methods[25]. Three models [26-28] for generic instructional strategies were presented for concept learning.

Some of these names relate to the process while others relate to the end result. Creative thinking, the subject of our concern, has also been referred to as 'concept learning' and 'generic learning'. Varied definitions of the word concept exist in the literature. Further, some concepts are taught as facts in the learning of complex concepts, adding ambiguity to the meaning of concept learning. Therefore, the name "Generic Learning"[29] was chosen for the creative thinking process that requires organization and manipulation of

knowledge acquired.

Some believe[15] that excessive empnasis on creativity is likely to destroy the basic cohesiveness needed for society to provide an opportunity for its members to achieve self-fulfillment. How much emphasis must one give to creativity – that quality unique to human beings and indispensable for survival and development?

REFERENCES

1. Bluck, R.S., Plato's Meno, with text and notes, Cambridge University Press, Cambridge, 1961.

2. Conford, F.M., Before and After Socrates, Cambridge University Press, Cambridge, 1932.

3. Young, D., Chem. Brit., 9, 166, 1973.

4. Learning to Be: Cultural Identity and the Community College, Report on the Canadian Community College Institute Seminar, Banff, 1974, p. 34

5. For a concise interpretation of Plato's theory of education see Brunbaugh, R.S., Lawrence, N.M., Philosophers on Education, Hughton, Mifflin Co., Boston, 1963

6. Faur, E. et al., Learning to Be, Ontario Institute for Studies in Education, Toronto, 1972, p. 136.

7. Ibid, p. 184.

8. Bloom, B.S. et al., Taxonomy of Educational Objectives, I Cognitive Domain, David McKay Co. Inc., New York, 1956.

9. Ibid, II, Affective Domain, 1964, p. 4.

10. Dewey, John, How We Think, D.C. Heath and Co., New York, 1933.

11. Taba, Hilda, Teaching Strategies and Cognitive Functioning in Elementary School Children, Cooperative Research Project No. 2404, U.S. Office of Education, Washington, D.C., 1966.

12. Bruner, J.S. et al., A study of Thinking, Science Editions, New York, 1962.

13. Suchman, R., Inquiry Training, Merrill-Palmer Quarterly, 1961, p. 147.

14. Crutchfield, R.S., Nurturing the Cognitive Skills of Productive Thinking, in "Life Skills in School and Society", Ed. L.J. Rubin, National Education Association, Washington, D.C., 1969.

15. Von Haden, H.I., King, J.M., Education Innovator's Guide, C.A. Jones Publishing Co., Worthington, Ohio, 1974, p. 353.

16. McCormack, A.J., J.C.S.T., 4, 10, 1974.

17. Johnson, D. and Fogel, M., J. General Psychol. 91, 93, 1974

18. Piaget, J., and Inhelder, B., The Growth of Logical Thinking From Childhood to Adolescence, Basic Books Inc., New York, 1958.

19. Piaget, J., Intellectual Evolution from Adolescence to Adulthood, Proceedings of the III Foneme International Convention of Human Formation from Adolescence to Maturity, Milan, May, 1970.

20. Osborn, A.F., Applied Imagination, Scribner and Son, New York, 1963.

21. Gordon, J.J., Synectics, Synectics Inc., Cambridge, Massachusetts, 1961.

22. de Bono, E., The Use of Lateral Thinking, Pelican Books, Middlesex, England, 1967.

23. Martovella, P.H., Concept Learning, Intex Educational Publishers, Toronto, 1972.

24. Postman, N.Y., and Weingartner, C., Teaching as a Subversive Activity, Delta Publishing Co. Inc., 1969.

25. Shulman, L.S. and Keislar, E.R., Learning by Discovery, Rand McNally, Chicago, Illinois, 1966.

26. De Cecco, J.P., The Psychology of Learning and Instruction, Englewood Cliffs, N.J., Prentice Hall Inc., 1968.

27. Gagne, R.M., The Conditions of Learning, Holt, Rinehart and Winston Inc., New York, 1968.

28. Taba, H., et al., A Teacher's Handbook to Elementary Social Studies, Addison-Wesley Publishing Co. Inc., Reading, Massachusetts, 1971.

29. Bruner, J.S., Learning and Thinking, Harvard Educational Review, 29, 184 (1959).

DAASAN APPROACH

The cognitive and philosophical considerations dealt with in the introduction led us to the following conclusions:

1) Basic education, while dispensing fundamental knowledge must endeavor to instil a taste for self-learning.
2) Learning situations that afford the students an opportunity to actualise their thinking powers help them in developing techniques of self-learning.
3) Generic Learning situations help students actualise their intuition and thinking powers.
4) Overemphasis on creativity is undesirable.
5) Educational objectives are useful in the analysis of instructional procedures
6) Detailed and specific behavioural objectives identify the body of knowledge to be mastered.

A teaching method that is consistent with the above conclusions ought to have two kinds of strategies: i) Strategies to dispense knowledge, ii) strategies to promote Generic Learning. Incorporation of these two kinds of strategies into a teaching method requires that the course content be divided into two groups: a) Concepts to be acquired as facts b) concepts to be acquired through Generic Learning Situations. An 80%, 20% respective distribution was tried in our experiment. This experiment was carried out in general C.E.G.E.P. (College d'Enseignement Général et Professionel) science and mathematics courses. All 37 C.E.G.E.P.s and about 17 private Colleges in the Province of Quebec follow the same course outlines (See Appendix I). Each course lasts for 15 weeks with 3 hours per week theory and 2 hours per week laboratory instruction. Most of the experimental sections were part of multiple sections offered in a course. To enable us to fulfil the

curricular requirements of the course within the specified time period and pedagogical restraints it became necessary to direct the activity in "Generic Learning" situations. Thus the Generic Learning situations used in "Directed Activity to Acquire Specific Abstractions in Nature" (DAASAN) Approach not only help the student actualise his/her intuition in formulating the required concept (abstraction) but also ensure that the student has acquired the concept (Fig. 1).

TEACHING STRATEGIES

Once all the concepts involved in a course are identified, Bloom's Taxonomy of educational objectives[8] may be used to achieve the above mentioned 80%, 20% distribution.

STRATEGIES TO DISPENSE KNOWLEDGE

Lecture method, the most common method used by teachers, relies mainly on the spoken word to identify the body of knowledge to be mastered by the student. Methods based on behavioristic models identify the knowledge to be mastered by specifying terminal behavioral objectives. Either method could be used in identifying the concepts (80%) to be acquired as facts.

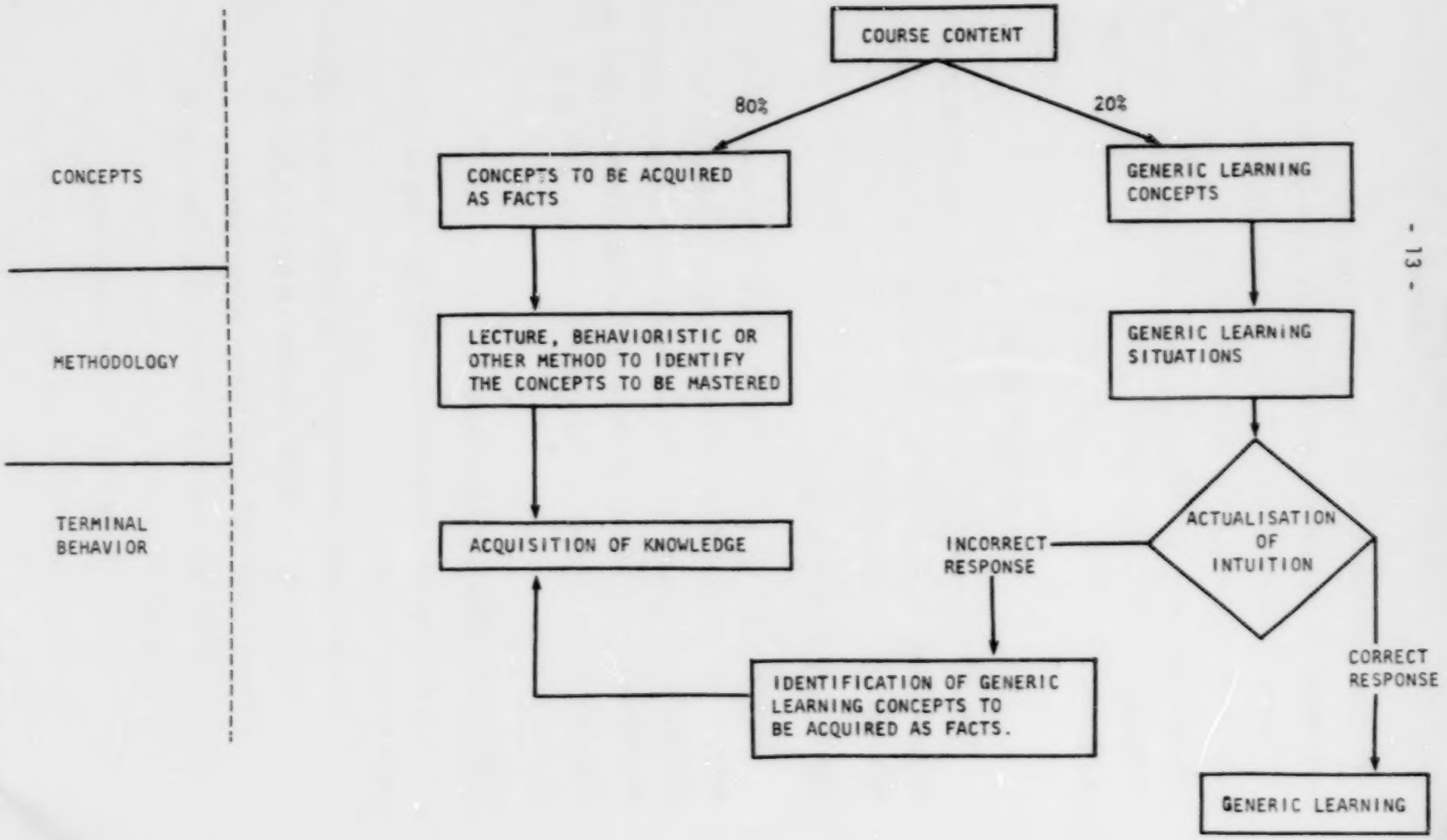
STRATEGIES TO PROMOTE GENERIC LEARNING

In developing Generic Learning situations the following points should be kept in mind:

i) Generic Learning situations help the student actualise his/her intuition, therefore, the situation should have a terminal objective that is to be discovered by the student.

ii) The student should be told about the global objective only, e.g. To analyse, synthesize or evaluate a situation, to apply a law, etc. (In the beginning the terminal objectives of Generic Learning situations are known to the teacher only).

FIGURE 1: DIVISION OF COURSE CONTENT



iii) The time that an average student might take to solve the situation in the class should be kept in mind. Complex concepts that take a long time to discover should be broken down into less complex ones.

iv) Immediate verification/correction mechanism must be provided. (Fig. 2).

v) The student should have a knowledge of prerequisite concepts.

Concepts related to application, analysis, synthesis and evaluation lend themselves easily for presentation in Generic Learning Situations.

IN THE LABORATORY:

Many commercially available laboratory manuals describe explicitly each step to be done in the procedure for each experiment. This often causes frustration in students because they have to do things mechanically. For this and other reasons ideally it is best to put a laboratory manual together that is to be used in a given course. Such a laboratory manual will have experiments designed to train the student in skills which they will subsequently make use of to discover other relationships.

Projects and open-ended experiments are known to promote discovery. There are several other ways of promoting Generic Learning. Before giving the procedure to determine a particular physical property the student may be asked to develop his own procedure. Similarly he may be asked to develop his own procedure for analysis type experiments. Instead of asking the student to prove a law, he may be asked to discover a regularity, if any exists, and state it in the form of a law.

MULTI STAGE GENERIC LEARNING SITUATION

DAASAN APPROACH

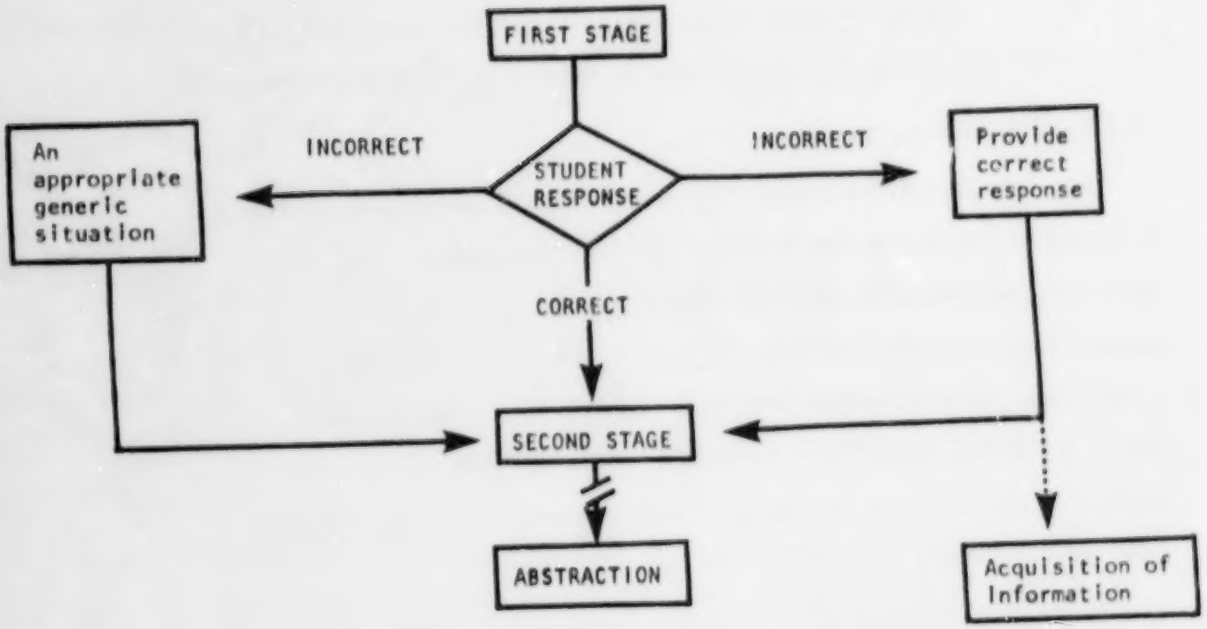


Figure 2

TESTING

A question in an examination that most students find difficult to answer is most likely the one that requires organisation of several concepts. Such a question can always be broken down into a group of questions that eventually help the student answer the original question. It is obvious that the student who can answer the original question on the first attempt, and the student who can answer the original question through a series of sub-questions, (clues), have different abilities. Inability to answer the question on the first attempt may be because of the students' inability to apply his knowledge. Thus we can identify two broad groups of students that a "difficult question" cannot distinguish. 1) students that have the basic knowledge but lack ability to apply it and 2) students that do not have the basic knowledge. To distinguish between these two different groups and to properly reward students with different abilities to apply their knowledge, "Generic Questions" could be used. Generic Questions may be constructed in the following fashion.

1. Find a question on a topic that relates several basic concepts.
2. Identify all concepts and place them into a hierarchical order.
3. Decide the step that corresponds with testing of knowledge acquired in that course, and discard all other lower steps.
4. Prepare questions and clues to all the concepts and place them in a decending order of difficulty.
5. Distribute the marks so that the original question carries the maximum amount and the question that tests for knowledge has just a pass mark.
6. When the Generic Question is administered the student is told that he can get clues, one at a time, at the expense of a few marks. (Fig. 3)

TWO STEP GENERIC QUESTION

(DAASAN APPROACH)

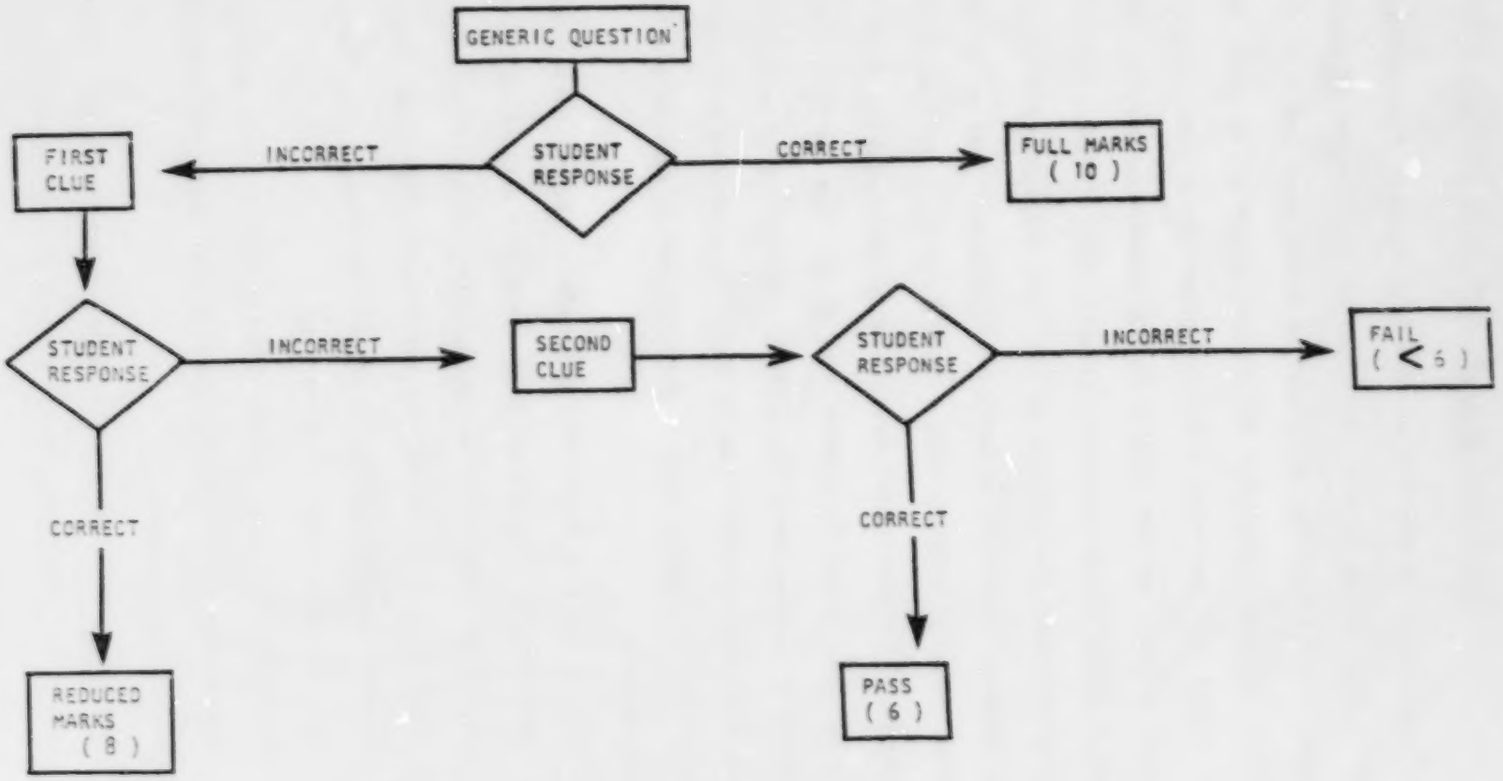


Figure 3

GENERIC LEARNING SITUATIONS

The following are some of the "Generic Learning Situations" that were used in mathematics and science courses. These were used

al aspects
n an
rded here.
he reader
tive,
' and
e of the
ned. A

ERRATUM

PAGE	LINE
21	Last line
26	line 13
53	line 6
55	line 18
55	line 19
87	missing last line

ERRATUM

PAGE	LINE	SHOULD READ
21	Last line	is less than a 1% chance that there is no correlation
26	line 13	when values of B(0), R(0), α, β, C, S are
53	line 6	"Getting a no-six" on one trial does not affect the
55	line 18	$H_0 : \mu = 3000$ ft/sec.
55	line 19	$H_A : \mu \neq 3000$ ft/sec.
87	missing last line	simple statements of facts, but to question why?

GENERIC LEARNING SITUATIONS

The following are some of the "Generic Learning Situations" that were used in mathematics and science courses. These were used in conjunction with lectures. Only the important and general aspects are covered here. Much learning activity that took place in an unstructured way within the structured pattern was not recorded here.

The situations are presented here in such a way that the reader should be able to obtain enough information about the objective, prerequisite knowledge, method of presentation and students' and teacher's opinion on the success of the situation. The name of the teacher and the course in which it was used are also mentioned. A detailed course description can be found in Appendix I.

CONTRIBUTOR	DISCIPLINE
Grant Brown	Mathematics
Klaus Dichmann	Chemistry
Keith Fern	Biology
Shastry Jandhyala	Mathematics
Jan Janmohamed	Chemistry
Gerry Portner	Physics
Subbanna Vadlamudy	Chemistry
Eleanore Van Norman	Biology
Sanford Witherell	Biology

INTRODUCTION TO APPLIED MATHEMATICS

GRANT BROWN

MATHEMATICS 201-101-73

The objective of the 201-101-73 course is to acquaint the student with mathematical methods used to solve a variety of problems that arise in physical, biological and social sciences. The topics covered are solving non-linear equations, statistics, operations research, and mathematical models. The student is required to analyse and solve problems of some consequence as part of the course work. To this end six projects were designed on different topics in which the student uses his own data, performs certain calculations and analyses the results. In order to help the students concentrate on the use of the mathematical tools, the actual calculations were done on a mini-computer. The computer was also used for simulation purposes. The general prerequisite to take the course is Functions. The topic on which the project is based on, naturally, also a prerequisite and was dealt with in the class.

Three of the six projects are described below:

PROJECT I

Purpose: To obtain information on movement of neutrons in the lead wall of a reactor.

Description: A neutron enters the lead wall, hits a lead atom, and bounces off that lead atom. The neutron "scatters" in a random direction, travelling a fixed distance, and then hits another lead atom.

After 10 hits, the neutron will die. But before some neutrons die, they will have been bounced back inside the reactor. Other neutrons will have been bounced through the lead wall to the outside.

Problem: How thick should the wall be in order to make sure that only a small percentage of the neutrons will pass through it?

Solution: Use computer simulation, using RANDOM NUMBERS TO SIGNIFY THE DIRECTION AND DISTANCE THAT A NEUTRON TRAVELS (THIS METHOD IS OFTEN CALLED MONTE CARLO METHOD). Use the programme to shoot 100 neutrons at the wall, and see how many pass through. Do this for several thicknesses. Draw conclusions.

Instructions:

1. Sign up for one of the 100 different "Angles of Impact" (i.e., the angle each of your neutrons will initially have).
2. Press RUN and EXECUTE to enter the value of your angle of impact.
3. Press GREY KEY 0 if you want to play around.
4. Press GREY KEY 15 for serious work.
5. Try several values for the thickness in such a way that the number of escaped neutrons ranges from 1 to 30.

   Obtain at least 10 measurements that make sense (i.e., not too many Zero's).

6. Record your measurements in a table:

x = Thickness	y = ln (number of escaped neutrons/100)
x_1 = ———	y_1 = ———
x_2 = ———	y_2 = ———
.	.
.	.
x_n = ———	y_n = ———

7. Graph those n points (x_i, y_i)

8. Find the least squares line $y = ax + b$ for those n points:

   Use the desk calculators to find

$$\sum_{i=1}^{n} X_i \; ; \; \sum_{i=1}^{n} Y_i \; ; \; \sum_{i=1}^{n} X_i^2 \; ; \; \sum_{i=1}^{n} Y_i^2 \; ;$$

$$\text{AND} \quad \sum_{i=1}^{n} X_i Y_i$$

Then:

$$a = \frac{n(\Sigma X_i Y_i) - (\Sigma X)(\Sigma Y_i)}{n(\Sigma X_i^2) - (\Sigma X_i)^2}$$

$$b = \frac{(\Sigma Y_i) - a(\Sigma X_i)}{n}$$

9. Compute the coefficient of correlation

10. Compare your value of r with the critical levels of r (last page of this material). Your value of df is n - 2. In that line of the table, there are two values, $r^*_{.05}$ and $r^*_{.01}$

    If $r > r^*_{.05}$ then there is less than a 5% chance that there is no correlation if $r > r^*_{.01}$ then there is less than a 1% chance that there is

11. According to all of the above work, how thick should the wall be if not more than one out of every million neutrons will escape?

Opinion: Computer simulation really helped the students by visualising the collision process and giving the aura of reality to all the complicated calculations. Each student worked with a different angle of impact and the final discussion of all the findings proved to be most interesting.

PROJECT 2

Purpose: To examine a Markov process.

Description: Assume that there are 3 manufacturers of widgets (Atomic Widget Company, Bacteriological Widget Company, and Chemical Widget Company - Abbreviated as companies A, B, and C).

Assume also that each company's share of the market in year i + 1 is completely determined by the companies' share of the market in year i according to a 1st order Markov Matrix of transition probabilities.

Problem: According to the text, there might be an equilibrium condition ("steady state") if none of the companies alters the matrix of transition probabilities. Find the steady state if it exists. Determine whether this steady state is unique or not.

Solution: By using the computer to calculate, from initial market shares in year 0, what each companies share of the market will be in years 1, 2, 3, ...etc.

Do this for several different initial shares of the market (See Instruction 6).

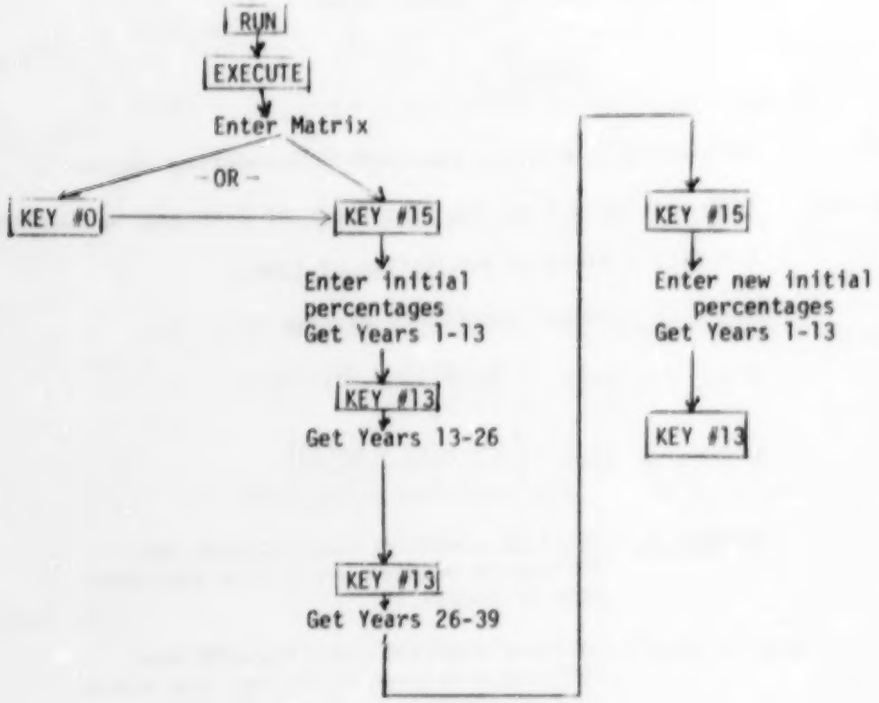
Draw conclusions.

Instructions:

1. Sign up for one of the 100 different matrices.
2. Press RUN and EXECUTE; enter your matrix
3. Press grey key #0 to play around
4. Press grey key #15 for serious work. When you press #15, the computer will ask you to "specify what percent of the market each company has initially".

The 3 percentages must add up to one.

After you give these 3 percentages, the screen will display the results for the next 13 years. If you want the results for year 13 to 26, press key #13. If you want the results for years 26 to 39, press key #13 again. Etc.



6. Try each of the following initial percentages:

A:	1	0	0	.5	.25	.25
B:	0	1	0	.25	.5	.25
C:	0	0	1	.25	.25	.5

Do you get a "steady state" for each of these?

Is it the same "steady state" each time?

What happens when you give the steady state as the initial market percentages?

7. Describe how you would prove that the "steady state" you found is unique.

8. Give an example of a Markov Matrix that leads to more than one "steady state".

PROJECT 3

Purpose: To examine population growth for 2 competing species.

Description: From section 8.3 of the text (case of 2 competing species),

$B = B(t)$ = Bluegill population at time t

$R = R(t)$ = Redear population at time t.

$$B'(t) = k \cdot B(t) \cdot \left(\frac{C - B(t) - dR(t)}{C} \right)$$

$$R'(t) = v \cdot R(t) \cdot \left(\frac{S - R(t) - bB(t)}{S} \right)$$

Where k = Positive constant (dealing with the difference between birth rate and death rate of Bluegill)

v = Positive constant (dealing with the difference between birth rate and death rate of Redear)

c = Maximum possible Bluegill population

s = Maximum possible Redear population

α = Positive constant (dealing with the ability of Redear to "squeeze out" Bluegill)

β = Positive constant (dealing with the ability of Bluegill to "squeeze out" Redear

Since $B'(t)$ is the rate of increase at time t, then according to our assumptions, $B(t+1)$ should be $B(t)+B'(t)$.

Similarly, $R(t+1) = R(t) + R'(t)$

Problem: In the text, 4 basic cases are considered:

CASE I: $S > \frac{C}{\alpha}$ and $C < \frac{S}{\beta}$ (fig. 8.8, 8.9, 8.10)

CASE II: $S < \frac{C}{\alpha}$ and $C > \frac{S}{\beta}$ (fig. 8.8)

CASE III: $S > \frac{C}{\alpha}$ and $C > \frac{S}{\beta}$ (fig. 8.8, 8.11, 8.12)

CASE IV: $S < \frac{C}{\alpha}$ and $C < \frac{S}{\beta}$ (fig. 8.8)

CASES I, II, and III are solved in the text. CASE IV is not solved in the text.

Solution: Part 1: By graphical techniques (as in the text), solve problem 8.11 (

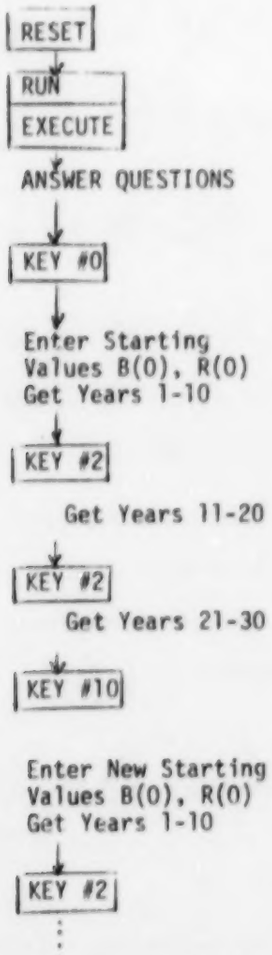
Part 2: By computer simulation: the computer will calculate B(1), R(1)
B(2), R(2)
⋮

When values for B(0), R(0), , B, C, S are specified (k = v = .75 in the programme).

Instructions:

1. Sign up for one of the 100 different sets of data (α, β, C, S)
2. Solve problem 8.11 in general
3. Use the computer and your set of data to verify your conclusions obtained in solving problem 8.11 (i.e. the graph in Case IV is divided into 4 regions; what happens when you take starting values B(0), R(0) from each of the 4 regions?)

4. USING THE COMPUTER:



5. The programme gives values for B(t) and R(t) in integers only (i.e. if B(t) = 500 and B'(t) = 23.67, then B(t +1) = 500+24 = 524).

   Discuss this complication.

Opinion: In projects 2 and 3 students had an opportunity to apply the concepts that they had learned in the course and make value judgements of their results. Further, group discussion of all the different results led to a deeper understanding of the principle. Again, the computer helped in the physical interpretation of graphs and equations which would otherwise have been abstract.

The text book that was referred to in the projects is "Perspectives in Mathematics", by D.E. Penney, W.A. Benjamin Inc., Menlo Park, California, 1972.

GENERIC LEARNING SITUATIONS IN GENERAL CHEMISTRY

KLAUS DICHMANN CHEMISTRY 202-201-73

The generic learning situations presented in Chemistry 201 were divided into three categories. Situations were presented in the classroom in the form of discovery lecture material, problem solving sessions and free classroom discussion. In the laboratory situation, experiments were presented where the students would discover laws of equations and also determine unknowns, once the procedure had been learned using known materials. The third type of situation was the expansion of the course material using homework assignments and problems. Although the homework situation had the least teacher control, it had the advantage that there was little, if any, time constraints placed on the student.

All of the situations presented here were used in Chemistry 201 during the 1975-76 school year and were presented to 2 sections of 201 for a total of approximately 55 students.

The text book referred to in all cases is Chemical Principles, W.L. Masterton and E.J. Slowinski, W.A. Saunders Co., Toronto, 1973.

CLASSROOM SITUATIONS

1) DETERMINATION OF G.M.W. FROM COLLIGATIVE PROPERTIES OF SOLUTIONS

Prerequisite Concepts:

1) $\Delta T_f = R_f \cdot m$

$\Delta T_b = R_b \cdot m$

$VPL = X_2 \cdot P_1^o$

$\Pi = MRT$

2) Concentration Units: m, X_i and M

3) mole concept: moles = g/GMW

Situations: Problems were presented which required the determination of the GMW of the Solute from colligative properties.
Ref: M & X # 10-17, 10-18, 10-19

Presentation: In each problem the student should have been able to calculate m, X_i or M. The problem presented to the student was then essentially to relate m, X_i and M to GMW. Hints given: moles = g/GMW

Opinion: In general the students were at a loss without the reminder: g/GMW = # moles. With this hint the problems went smoothly.
With several problems some of the better students had finished before others had completed the first problem. This created some confusion in the classroom and this type of situation is most effective if student-student interaction takes place (i.e. the faster students presenting hints to the slower students). This was done in subsequent situations and the student response was much better but there was a certain loss of control of the situation by the instructor.

ii) <u>COLLIGATIVE PROPERTIES FOR ELECTROLYTES</u>:

Prerequisite Concepts:

1) Colligative properties

$\triangle T_f = R_f \cdot m$

$\triangle T_b = R_b \cdot m$ etc.

2) Net ionic equations

(i.e. how species ionize in solution)

3) Colligative properties $\propto$ number of species in solution.

Situation: Problems were worked in class requiring the Van't Hoff's i factor and calculation of % ionizations.

Ref: M & S # 11.9, 11.25

Presentation: The first step was the derivation of the colligative properties in terms of i.

Hints: (i) $MX \longrightarrow M^+(aq) + X^-(aq)$

(ii) properties $\propto$ # particles in solution

This led to the equations in the form.

$\Delta T_f = i K_f m$ etc.

Once i could be calculated the problem of what would happen if ionization was $\neq$ 100% was presented. This discussion led to the concept and procedure for calculation of percentage ionization.

Opinion: Most students (15 out of 25) reached the equations without hints and the remainder reached the results with the hints.

The calculation of % ionization from i presented some problems when the theoretical i values are greater than 2.

The students performed well in this situation.

iii) <u>THE GIBBS'- HELMHOLTZ EQUATION</u>:

Prerequisites: Knowledge of

(1) ΔH

(2) $+ T\Delta S$

(3) Role of ΔH and $T\Delta S$ in determining the spontaneity of a reaction

Situation: After the student has been presented with the concepts of ΔH and $T\Delta S$ and the driving force they represent for spontaneity, the student is asked to combine the two factors.

Presentation: Hints: (1) Reminder of ΔH and $+ T\Delta S$

(2) Suggestion of subtracting the factors

(3) $\Delta G = \Delta H - T\Delta S$

The student is asked to examine the sign of ΔG.

Hints: (i) Sign of ΔH for spontaneity

(ii) Sign of ΔS for spontaneity

(iii) Sign of ΔG?

The student is then asked to examine ΔG at equilibrium.

Hint: (i) $\Delta H = T\Delta S$

Opinion: The qualitative derivation of $\Delta G = \Delta H - T\Delta S$ was done by only 4 out of 25 students but after the first two hints all but five had derived $\Delta G = \Delta H - T\Delta S$. The sign of ΔG gave little trouble but the $\Delta G = 0$ at equilibrium was derived by only 13 out of 25 without the hint.

iv) CALCULATION OF ΔG AT TEMPERATURES OTHER THAN $298^{o}K$.

Prerequisites: (1) $\Delta G = \Delta H - T\Delta S$

(2) ΔS is essentially independent of temperature

(3) ΔH is essentially independent of temperature

Situation: The student is given ΔG^{o} and asked to calculate ΔG at a different temperature.

Ref: M & S # 12-11.

Presentations: Hints: (1) Calculate ΔG^{o} if not given

(2) Calculate ΔH^{o} if not given

(3) Calculate $\Delta S = \frac{(\Delta H^O - \Delta G^O)}{298}$

(4) Remember ΔH^O and ΔS^O are essentially temperature independent

(5) $\Delta G = \Delta H^O - T\Delta S^O$ for new temperature.

Opinion: Only two students out of 25 completed this situation without hints. Hint (3) was very important as many students got stuck after calculating ΔH^O and ΔG^O. In addition hint (5) was required for about 8 out of 25 students.

v) RELATIONSHIP BETWEEN Kp and Kc for GASEOUS EQUILIBRIA

Prerequisite Concepts
(i) Kp
(ii) Kc
(iii) $pV = nRT$
(iv) Δn gas.

Situations: After the presentation of Kp and Kc the students were asked to use the ideal gas law $PV = nRT$ to derive a relationship between Kp and Kc.

Ref: M & S # 13.38.

Presentation: The student has been presented with Kp and Kc and from the definitions it is seen that they must be related. The student is asked to start with

$$K_p = \frac{p_C^c \cdot p_D^d}{p_A^a \cdot p_B^b}$$

Hints: (1) $P_A = \frac{n_A RT}{V}$ etc.

(2) $\frac{n_A}{V} = [A]$ etc.

(3) $Kc = \frac{[C]^c [D]^d}{[A]^a [B]^b}$

(4) Δn = (moles gaseous products) - (moles of gaseous reactants)

Opinion: Hint #2 was the most important one with 15 out of 25 students requiring this clue. Otherwise it was well done with no more than 7-8 students requiring the other hints.

vi) DETERMINATION OF K_a FROM EXPERIMENTAL DATA

Prerequisite Concepts: (i) weak acids
(ii) K_a

Situation: Students are asked to write the expression for Ka and then to consider if they can design a simple experiment that will give Ka (or pKa) directly.

$$K_a = \frac{[H^+][A^-]}{[HA]}$$ Ref: M & S # 17.10)

Presentation: Hints: (i) Can we have an experimental arrangement where $K_a = [H^+]$?
(ii) How can you make $[A^-] = [HA]$?
(iii) Divide a given solution of acid into 2 equal parts and titrate one of them to neutrality.
(iv) Remix the parts together.

Opinion: Of the 25 students in the class, none were able to do this situation without hints (i) and (ii) and 20 required all the hints. The situation was very useful in reviewing Ka and equilibria. It showed even the excellent students that there was more to learn in visualising equilibrium situations. The students were in general disappointed in their own performances in this situation.

vii) RELATIONSHIP AMONG K_a, K_b and K_w

Prerequisite Concepts: (i) K_a

(ii) K_w

(iii) Manipulation of Ks when equations are added.

Situation: The expression for K_b was given as:

$$K_b = \frac{[HX][OH^-]}{[X^-]}$$

and the students were asked to derive a method of getting a numerical value of K_b from the K_a value of HX and K_w.

Presentation: Hints: (i) $H_2O + X^- \rightleftharpoons HX + OH^-$ K_b

(ii) $H_2O \rightleftharpoons H^+ + OH^-$ K_w

(iii) $H + X^- \rightleftharpoons HX$ $1/K_a$

(iv) add (ii) (iii) $H_2O + X^- \rightleftharpoons HX + H_2O$ $\frac{K_w}{K_a}$

(v) (iv) $\equiv$ (i) $K_b = \frac{K_w}{K_a} = \frac{10^{-14}}{K_a}$

Opinion: Of the 26 students, 10 were able to complete the assignment and 20 completed the situation with hint (iii). The reversal of the equation before addition appeared to stump many students.

viii) TITRATION CURVES FOR STRONG ACID/STRONG BASE

Prerequisite Concepts: i) definition of a strong acid

ii) definition of a strong base

iii) K for a strong acid/strong base reaction (10^{14}).

Situation: The following problem (M & S #18.11) was given to the students and they were asked to plot pH vs volume of base added.

"Fifty ml 0.1000 M HCl is titrated with 0.1000 M NaOH. Calculate the pH of the solution after the following volumes of NaOH have been added:

a) 0.00 ml
b) 25.00 ml
c) 49.90 ml
d) 29.99 ml
e) 50.01 ml
f) 50.10 ml
g) 75.00 ml
h) 100.00 ml

Presentation: Hints: i) the species dissociate 100%

ii) up to 49.99 ml $[H^+]$ in excess

iii) after 50.01 ml $[OH^-]$ in excess

Opinion: The calculations went easily with almost all students (20 out of 23) completing the assignment with only one hint or clue.

ix) TITRATION CURVE FOR WEAK ACID/STRONG BASE

Prerequisites: i) K_a

ii) K for weak acid/strong base reaction. $\frac{K_a}{K_w}$

Situation: The following problem (M & S #18.30) was presented to the students and they were asked to plot pH vs volume of NaOH added.

"Fifty ml of 0.2000 M CH_3COOH is titrated with 0.200 M NaOH. Calculate the pH of the solution after the following volumes of NaOH have been added:

a) 0.00 ml
b) 25.00 ml
c) 49.90 ml
d) 49.99 ml
e) 50.01 ml
f) 50.10 ml
g) 75.00 ml
h) 100.00 ml

Presentation:

Hints: i) $[H^+] = K_a \frac{[CH_3COOH]}{[CH_3COOH^-]}$ for a-d

ii) after 50.00 ml have been added there is excess OH^- from a strong base which dissociates 100%

iii) $[OH^-] = 0.20 \times \frac{\text{vol. excess NaOH}}{\text{total volume}}$

iv) pH = 14 - pOH

Opinion: Hint (i) was required by about 50% of the students (13 out of 24) and hint (ii) was required by 12 out of 24. There was difficulty in visualizing the difference in calculating for a weak acid from that for a strong acid. The plotting was done well by all students.

THE GENERIC LABORATORY SITUATIONS

1) Experimental Derivation of the Colligative Properties of Boiling Point Elevation and Freezing Point Depression.

Prerequisites: i) concentration units, m

ii) a set of experimental data for ΔT_f and ΔT_b

iii) graphing of a straight line y = mx + b

Situation: Students were asked to study the system ethylene glycol/water for boiling point elevation and the system naphthalene/benzene for freezing point depression. Experimental data were collected for each of these systems and the students were asked to plot ΔT_f vs m or ΔT_b vs m.

Hints: i) Plots should be straight lines. What are equations for ΔT_f and ΔT_b?

ii) The proportionality constant depends on the solvent.

Opinion: The situation worked well for ΔT_b but there were not enough data points for ΔT_f to give some students enough confidence to predict a straight line.

2) Do Rolaids Consume 47 Times Their Weight in Acid?

Prerequisites: i) concept of back titration

ii) acid/base titrations

iii) mass of a dilute acidic solution

Situation: Students determine in the laboratory the moles of HCl consumed per gram of tablet. Then given that stomach acid is 5.0×10^{-2} M and has a density 1.00 g/ml, the student is asked to justify "Rolaids consume 47 times its weight in excess stomach acid".

Presentation:

No hints were given in the laboratory and the students were left to do the best they could.

Opinion: Virtually all the students (22 out of 24) were able to justify the statement about Rolaids.

GENERIC SITUATIONS FROM ASSIGNMENTS

(1) Determination of Kp from the total pressure at equilibrium.

Prerequisites: i) Kp

ii) $PV = nRT$

iii) definition of X_i

Situation: The following problem was assigned:

"In an experiment, 0.631 g of phosgene is placed in an evaculated flask with volume 472 ml at 1000 K.

$$COCl_2\ (g) \rightleftharpoons CO\ (g) + Cl_2\ (g)$$

At equilibrium the total pressure is 2.18 atm.

Calculate Kp.

Stages: i) calculate moles $COCl_2$ (g)

ii) calculate total moles in terms of **X**

iii) solve for **X** using $PV = nRT$

iv) $P_i = X_i \times P$ total

v) calculate Kp.

Opinion: In this question neither Kp nor the concentration of equilibrium are given directly and the student must find a way to get the equilibrium conc. (expressed in terms of **X**) without having a Kp value. For 20 out of 23 students hints (i) - (iii) were required. The hints ~~or~~ were given on a separate sheet of paper and the students were asked to keep track of the number of hints that they used. I found that this procedure was very unsatisfactory since it was impossible to get student feedback during the situation and it was too easy for the students to go to the "hint" sheet.

GENERIC LEARNING SITUATIONS IN INTRODUCTORY CHEMISTRY

KLAUS DICHMANN CHEMISTRY 202-111-73

(1) Development of the Atomic Theory from the Laws of Chemical Combinations:

Prerequisites: (i) Law of Conservation of Matter
(ii) Law of Definite Composition
(iii) Law of Multiple Proportions

Situation: The students were presented with the 3 laws of Chemical Combination and were asked to derive a theory of "atomic" structure that would explain the laws.

Presentation: As clues and guides the main features of Dalton's Atomic Theory (present day form) were presented to the students. After each clue the students were asked to explain how it accounted for the observed laws of chemical combination.

Hints: (i) An element is composed of small particles. All particles (atoms) of a given element are chemically identical.
(ii) Atoms of different elements have different properties and atoms are not changed into atoms of another element during a chemical reaction.
(iii) Compounds are formed when atoms of more than one element combine.

Opinion: The students were familiar with the atomic theory and could repeat the principal features of the theory. However, many students (19 out of 30) could not visualize how it could be used to explain the laws of chemical combination.

(2) Calculation of Natural Abundance Values

Prerequisites: (i) atomic weights

(ii) isotopes

Situation: The students were asked to calculate the natural abundance values for C-12 and C-13 if the average atomic weight of carbon is 12·011.

Presentation: The following hints were presented

(i) let X be fraction of C-12

(ii) let 1-X be fraction of C-13

(iii) X(12) + (1-X)(13) = 12·011

Opinion: Virtually all the students had seen this "type" problem before, so it was difficult to evaluate the situation. Of the 32 students, 27 completed the problem without hints.

(3) Determination of Avogadro's Number from Solid State Data

Prerequisite: (i) definition of No.

(ii) simple cubic structures

(iii) density

(iv) atomic weight

Situation: Given that Ag has a simple cubic structure with $a=4{\cdot}06A^{O}$ and has a density of 10·64 g/cc calculate No.

Presentation: The following clues or hints were presented:

(i) calculate the number of atoms in one G.A.W. of silver

(ii) calculate the volume of 107·87 grams of silver

(iii) calculate volume of 1 atom

(iv) calculate the number of atoms in 107·87 g of silver

Opinion: Only 5 out of 33 students completed this situation without hints. About half (15 out of 33) needed the first three hints and only 5 required the final hint.

(4) Derivation of the Reduced Forms of the Ideal Gas Equation ($PV=nRT$)

Prerequisites: (1) Boyle's Law

(2) Charles' Law

(3) Avogadro's Law (Hypothesis)

(4) Combined Law

(5) "Unnamed Law" $P_1/T_1 = P_2/T_2$

Situation: The students were presented with the ideal gas law, $pV=nRT$, and were asked to derive all the above law by holding one or two of the variables fixed.

Presentation: The following hints were given:

(i) Boyle's Law: hold n and T fixed

(ii) n and T fixed .. PV=constant

(iii) PV=constant .. $P_1V_1 = P_2V_2$

(iv) Charles' Law: n and p fixed

(v) Avogadro's Law: P and T fixed

(vi) Combined Law : n fixed

(vii) Unnamed Law: n and V fixed

Opinion: Only 7 out of 32 students completed the assignment without the first 3 hints. With the first three hints, 25 out of 32 completed the situation without further clues.

(5) Solving Simple Stoichiometric Problems

Prerequisites: (i) mole concept

(ii) balanced chemical equations

(iii) G.A.W. and G.M.W.

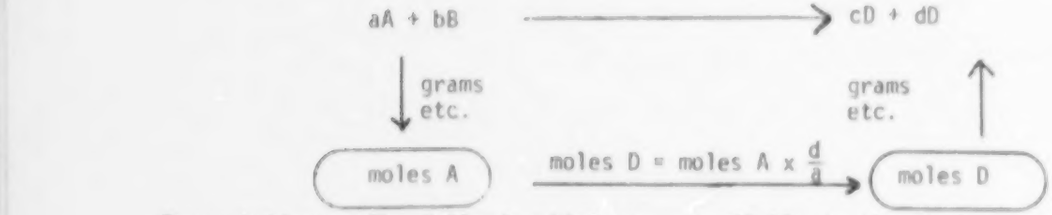
Situations: The students were asked to solve the following problem

"In a rocket propellant composed of hydrazine, N_2H_4, and hydrogen peroxide, H_2O_2, the reaction is

$$N_2H_4(l) + 2H_2O_2(l) \rightarrow N_2(g) + 4H_2O(l)$$

How many grams of water are formed if 15·0 g of H_2O_2 are consumed.

The students had also been presented with the following guide to solving stoichiometric problems.



Presentation: The following hints were available to the students.

(i) Moles of $H_2O_2 = \frac{15·0}{34·0} = 0·441$

(ii) Moles $H_2O = 0·441 \times \frac{4}{2} = 0·882$

(iii) Grams of water = 0·882 x 18 = 15·9

Opinion: Thirteen of 20 students completed the assignment without hints or clues. Two required the first two hints and the five remaining students required all three hints.

(6) Stoichiometry for Reactions that Form precipitates

Prerequisites: (1) mole concept

(ii) balanced chemical equations

(3) G.A.W. and G.M.W.

(4) stoichiometry

Situation: The students were presented with the following problem "A sample of impure NaCl weighing 1·00 g is dissolved in water and completely reacted with silver nitrate solution:

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

The dried precipitate of AgCl has a mass of 1·48 g. Calculate the % of NaCl in the impure sample."

Presentation: The students were presented with the following hints, if they were needed.

(i) Moles of AgCl = $1{\cdot}48 \times \frac{1}{143}$ = 0·0103

(ii) Mole NaCl = $0{\cdot}0103 \times \frac{1}{1} \frac{\text{moles NaCl}}{\text{moles AgCl}}$

= 0:0103

(iii) grams NaCl = 0·0103 x 58·4

= 0·604g

(iv) % NaCl = $\frac{0{\cdot}602}{1{\cdot}00} \times 100 = 60{\cdot}2\%$

Opinion: Of the 21 students present, 14 were able to complete the assignment without clues or hints. Four students required the first two hints and three students required 3 clues.

This was the second problem on stoichiometry with the performance almost identical to the found in situation (5).

(7) The Stoichiometry of Titration Reactions

Prerequisites: (1) Molarity

(2) balanced chemical equations

(3) stoichiometry

(4) G.A.W. and G.M.W.

Situation: The students were asked to solve the following problem. "A 0·660 M NaOH solution is used to determine the molar concentration of an H_2SO_4 solution. What is the molarity of the acid, 200 ml of which is just neutralized by 36·0 ml if standard base?"

$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

Presentation: The students were provided with the following hints, if required:

(i) Moles NaOH $= 0{\cdot}660 \frac{\text{moles NaOH}}{1} \times 36 \times 10^{-3}\text{l}$

$= 0{\cdot}0238$ moles

(ii) Moles H_2SO_4

$= 0{\cdot}0238 \times \frac{1 \text{ moles } H_2SO_4}{2 \text{ moles NaOH}}$

$= 0{\cdot}0119$ moles

(iii) Molarity $= \frac{\text{moles}}{1} = \frac{0{\cdot}0119}{0{\cdot}020} = 0.595\text{M}$

Opinion: This was the third example of stoichiometry, presented in a generic fashion. In this case, all but 8 out of 22 students completed the assignment successfully. Five required hint number two, and three students required only hint #3. It appeared that the students were developing the ability to handle stoichiometric problems.

(8) The Limiting Reagent in Stoichiometry Reactions

Prerequisites: (1) Stoichiometry of chemical reactions

(2) Definition of a limiting reagent

Situation: The students were asked to solve the following problem: "Zinc (Zn) reacts with silver nitrate solution according to the following reaction,

$$Zn(s) + 2AgNO_3\ (aq) \longrightarrow 2Ag(s) + Zn(NO_3)_2\ (aq)$$

7·35 g of solid zinc is placed in 100 ml of 2·0M silver nitrate. How many grams of Ag will be produced?

Presentation: The following hints were provided to the students if they were required:

(i) Moles of Zn = $\frac{7.35}{65.4}$ = 0·112 moles

Moles $AgNO_3$ = ·100 x2·0 = 0·200 moles

(ii) 0·112 moles Zn requires 0.224 moles $AgNO_3$ .. $AgNO_3$ is the limiting reagent.

(iii) Moles Ag = moles $AgNO_3$ = 0·200 moles

(iv) Grams Ag = 108 x ·2 = 21·6g

Opinion: This was the fourth problem on stoichiometry and continued improvement in students' results was seen. Eighteen out of 22 students completed the situation successfully. The remaining four required only hint #2.

Comments on Generic Learning Situations in the Classroom

In general I found students were uncomfortable with the generic approach. The difficulty appeared to be due mostly to pacing. The students who had completed a generic situation were forced to wait or go on to another part of the course material while the rest of the

class completed this assignment.

This difference in pacing requires a great deal of organization of the material on the part of the instructor and a structure whereby students can work at their own pace without feeling that they are holding back the rest of the class.

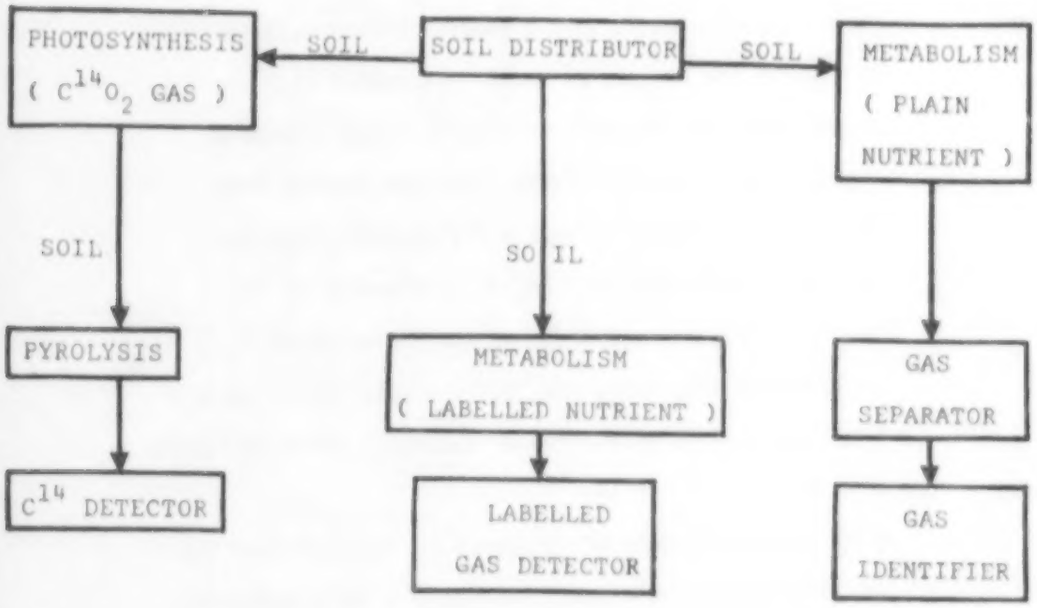
One solution to this pacing problem appears to be the P.S.I. approach. Here the students can work at their own pace under either carefully monitored conditions, or simply by himself. I plan to teach using P.S.I. methods and will try to incorporate "Generic Learning Situations" into the material.

THREE TESTS FOR LIFE

KEITH FERN

BIOLOGY 101-301-73

The following diagram was extracted from an article entitled "Looking for Life on Mars" in a recent edition of "Time" magazine. It represents three tests for life which will be performed when Lander 1 descends to Mars' surface on July 4, 1976.



Using the knowledge gained at the beginning of this period along with your intuitive abilities, attempt to describe how each of the three tests (one for photosynthesis, two for metabolism) will be executed. Enough clues should be available in the diagram.

Before handing them this sheet a forty minute discussion was carried out on the following topics:

a. An overview of photosynthesis and cellular respiration

b. Carbon - 14 labelling

c. Gas analysis techniques.

The answers were collected at the end of the session and graded out of a total of ten points.

Opinion: There is a need early in all general biology classes to discuss the concept of "what life really is." In actual fact, all students, including those without a biology course in their background, can provide some "fuel for the flame" in such a discussion. With this in mind, I felt that if I could add somewhat to their presently existing knowledge at the beginning of a class period they would then be in a position to solve a problem dealing with a few of the basic characteristics of life.

After evaluating each of 29 papers I concluded that the session had been relatively successful. Most appeared to have a good sense of exactly how the tests for life were to be carried out, although I decided that very few (three students) should receive a perfect mark for their work.

The results of a student evaluation pertaining to this session were encouraging. Although only 3/23 (13%) of the students who responded to the questionnaire greatly enjoyed the session, 16/23 (70%) enjoyed it reasonably

well. On the other hand, the remaining 4/23 (17%) did not find it to their liking.

In response to a question comparing this session to a lecture that might have been given on the same topic, I received the following interesting results:

7/22 (31%) of the students felt that without a doubt they learned more than they would have in a lecture:

12/22 (55%) thought they possibly learned more;

1/22 (5%) felt that a lecture would have better benefited them; the remaining 2/22 (9%) were undecided.

CLASSIFICATION OF ORGANISMS

KEITH FERN

BIOLOGY 101-301-73

Each student was given an identification key entitled "Key for the Classification of the Major Groups of Animals" extracted from the Guide for Laboratory Studies/Biological Sciences, Lawson et.al., Michigan State College Press, Mic. 1951. After distributing the keys I showed the students how to use them by demonstrating how to classify two preserved specimens.

The following 15 organisms were to be properly classified by each student using the systematic approach already taught:

1. turtle
2. centipede
3. spider
4. land snail
5. marine sponge
6. edible mussel
7. perch
8. locust
9. starfish
10. roundworm
11. earthworm
12. crayfish
13. sea urchin
14. frog
15. liver fluke

During the last 15 minutes of the period the students were asked to characterize, without the use of the kay, 5 out of the following nine phyla and classes using thehheadings; symmetry, digestive tract, external structures and segmentation or nonsegmentation:

1. Annelida
2. Arthropoda
3. Mollusca
4. Platyhelminthes (flatworms)
5. Hemathlminthes (roundworms)
6. Chordata
7. Porifera
8. Echinodermata
9. Insecta

The idea here being that, as a result of the use of the key, the students should remember many of the observed characteristics and be able to associate them with varoius phyla or class names such as those listed on the previous page.

Opinion: It is my opinion (formed from student responses in past semesters) that lectures pertaining to the classifications of organisms are the least well received. For this reason I felt it necessary to devise a method to deal with the classification issue that would actually be an enjoyable learning experience for the students.

After appraising their characterizations of the phyla, I reached the conclusion that the students did in fact gain a fair amount from the session. Although no one received full marks for their effort, most scored between seven and ten out of a possible ten.

The responses to the confidential questionnaire concerning this session were very positive: approximately 48% (11/21) enjoyed the period very much; nearly 33% (7/21) enjoyed it reasonably well; the remaining 19% (4/21) indicated some discontent.

More importantly, 43% (9/21) indicated that they felt, without a doubt, they learned more in this session than they would have inaa lecture session on the same topic. Another 43% (9/21) felt that possibly this was so. Only 5% (1/21) felt that they would have learned just as much or more in a lecture session. About 10% (2/21) were undecided on the session's merits as a learning tool.

STATISTICS

SHASTRY JANDHYALA MATHEMATICS 201-337-73

The following problems were used to illustrate the application of some of the concepts learned in this course. The students were led through the steps using appropriate questions and hints.

i) PROBABILITY

Suppose a fair die is rolled. How many rolls (throws) do you need so that the probability of getting at least one six equals .98?

Step 1 n = number of rolls

p (getting at least one six in n rolls) = .98

Step 2 x = number of sixes (random variable)

The events, "getting six" and "not getting six" are mutually exclusive events.

i.e. $P(6) = \frac{1}{6}$; $P(\bar{6}) = 1 - \frac{1}{6} = \frac{5}{6}$.

Step 3 $\sum_{i=1}^{n} P(x_i) = 1$. (The sum of the probabilities of all events in an experiment must be equal to 1)

Step 4

X	P(X)
0	P(0)
1	P(1)
2	P(2)
.	.
.	.
.	.
n	P(n)

If you roll the die n times, these are the possible events and the corresponding probabilities of the random variable.

Eg: P(0) means the probability of "no sixes" in n rolls; P(1) is the probability that exactly one-six in n-rolls; etc.

$P(0) + P(1) + P(2) + \ldots P(n) = 1$ (definition Step 3)

Step 5 P (at least one six in n trials)

$= P(x \geq 1) = .98$

Step 6 $P(x \geq 1) = 1 - P(0) = .98$

i.e. $P(0) = .02$

This is to say the probability of getting no sixes in n trials is equal to 0.02.

Step 7 $P(\bar{6}$ and $\bar{6}$ and $\bar{6}$ . . .$) = .02$

"Getting a no-six" on one trial does affect the probability of "getting a no-six" on the second trial - (independent events).

Step 8 $\underbrace{P(\bar{6}) \cdot P(\bar{6}) \ldots P(\bar{6})}_{\text{n-rolls}} = .02$

$$\underbrace{\left(\frac{5}{6}\right)\left(\frac{5}{6}\right)\ldots\left(\frac{5}{6}\right)}_{\text{n rolls}} = .02$$

$$\frac{5^n}{6} = .02$$

Step 9 $a^x = b$

Taking logs

$x \text{ Log } a = \text{Log } b \qquad x = \frac{\log b}{\log a}$.

$$(.83)^n = .02$$

$$n \text{ Log } (.83) = \text{Log } (.02)$$

$$n = \frac{\log (.02)}{\log (.83)} = \underline{21}$$

ii) PROBABILITY

The probability that a certain door is locked is $\frac{1}{2}$. The key to the door is one of the 10 unidentified keys hanging on a key rack.

Two keys are selected at random before approaching the door.

What is the probability that the doorway be opened without returning for another key?

Step 1 P (door is locked) = $\frac{1}{2}$ = P(L)

P (right key) = $\frac{1}{10}$

Probability that you will not return for a third key = ?

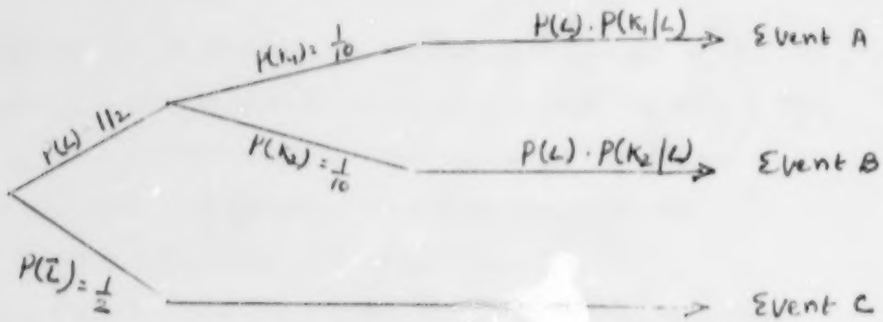
Step 2 P(door is not locked) = P($\bar{L}$) = 1 = $\frac{1}{2}$ = 1/2

Random selection of the two keys K_1 and K_2

P (K_1 is the right key) = $\frac{1}{10}$ = P (K_1)

P (K_2 is the right key) = $\frac{1}{10}$ = P (K_2)

Step 3 Draw a tree diagram and see how it looks.



Step 4 Events A, B and C are mutually exclusive. Within' events A and B, events "locked" and "K_1" and "locked" and "K_2" are independent.

Step 5 $P(A) = P(L \text{ and } K_1) = P(L) \cdot P(K_1) = \frac{1}{2} \cdot \frac{1}{10} = \frac{1}{20}.$

$P(B) = P(L \text{ and } K_2) = P(L) \cdot P(K_2) = \frac{1}{2} \cdot \frac{1}{10} = \frac{1}{20}$

$P(C) = P(\bar{L}) = \frac{1}{2}.$

$$P(A \text{ or } B \text{ or } C) = P(A) + P(B) + P(C)$$

$$= \frac{1}{20} + \frac{1}{20} + \frac{1}{2} = \frac{12}{20}$$

$$= \underline{0.6}$$

The probability that the door is opened without returning for a third key is 0.6

iii) TESTING A HYPOTHESIS

A manufacturer of gunpowder has developed a new powder which is designed to produce an average nozzle velocity equal to 3000 ft/sec. Eight shells are loaded with the charge and the nozzle velocities measured. The resulting velocities are as follows:

3005, 2995, 2925, 3005, 2935, 2935, 2965, 2905

Do the data present sufficient evidence to indicate that the average velocity differs from 3000 ft/second?

Step 1 Testing of hypothesis involving μ (average velocity)

Step 2 HO: $\mu =$ 3000 ft/sec.

HA: $\mu \neq$ 3000 ft/sec.

Sample size = n = 8

Step 3 Needed to know:

$$s^2 = \frac{\sum_{i=1}^{8} (x_i - \bar{x})^2}{n-1} \quad ; \quad \bar{x} = \frac{\sum_{i=1}^{8} x_i}{n} = 2957 \text{ ft/sec.}$$

$s = \pm 9.4$ ft/sec.

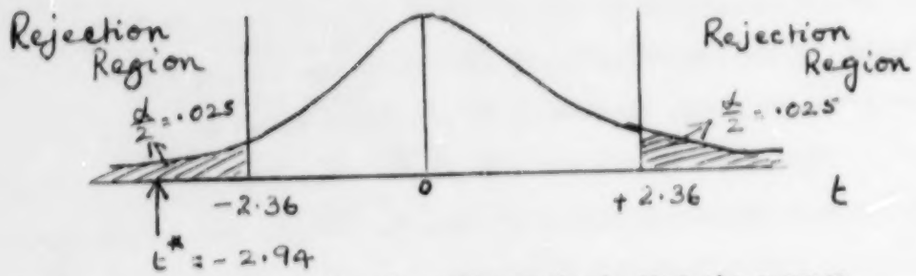
α = level of significance = .05 (at what level of significance would you like to test the hypothesis)

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$ (when $n < 30$, and the standard deviation of population is unknwon)

Step 4 $t^* = \frac{\bar{x} - \mu}{s/\sqrt{n}}$ where t^* refers to test statistic calculated from the sample data.

$t_{\alpha/2} = \pm 2.36$ (Critical values taken from the t - distribution tables for a two-failed-test and 7 degrees of freedom).

Step 5 $t^* = \frac{2959-3000}{\frac{39.4}{8}} = -2.94.$



Step 6 Decision: Reject the null hypothesis that the average nozzle velocity is equal to 3000 ft/sec.

Opinion: About 85% of the students in the class actively participated in the Generic Learning Situations. Of these, nearly 90% have expressed the opinion that this approach has encouraged them to think and they liked it.

COLLIGATIVE PROPERTIES

JAN JANMOHAMED

CHEMISTRY 202-201-73

This is the first course in which most students are introduced to colligative properties. A knowledge of definition of solvent, solute solution, ionization, concentration units and algebra is sufficient to be able to participate in this Generic Learning Situation.

Students were provided with copies of sheets containing hypothetical experimental data and a series of questions with enough space to answer. The students were asked to answer one question at a time without looking at the next question. Correct answer was given before the students proceeded to the next question. Here, for the reader's convenience the generic questions are identified with * and the clues are denoted by #.

GENERIC LEARNING SITUATION

Objective: To investigate the relationship, if any, between concentration of a solution and its physical properties. The boiling point of a pure solvent and solutions of different concentrations was determined. For three different systems the following results were observed:

DATA

Experiment 1. Ethanol-water system GMW H_2O = 18.0 g.

g of EtOH	g of H_2O	Boiling point ^oC	Change in boiling point ΔT_b
100	-	78.50	-
100	3.6	80.94	-
100	7.2	83.38	-
100	10.8	85.82	-
100	14.4	88.26	-

Experiment 2. Ethanol - non volatile liquid X System. GMW of X = 32.0

g of EtOH	g of X	Boiling point ^{o}C	Change in boiling point ΔT_b
100	-	78.50	-
100	6.4	80.94	-

Experiment 3. Ethanol - Aluminum bromide System. GMW $AlBr_3$ = 266.7 g

g of EtOH	g of $AlBr_3$	Boiling point ^{o}C	Change in boiling point ΔT_b
100	-	78.50	-
100	53.3	84.60	-

Questions: Experiment 1

1. What physical property are we measuring?
2. Identify the solute and the solvent.

   Solute _____ Solvent _____

3. Is the boiling point of solutions greater than or less than the boiling point of pure solvent?
4. Fill the following table using the data form experiment 1.

g of solvent	moles of solute	molality	Boiling point of solution ^{o}C	Elevation of Boiling point ΔT_b ^{o}C

5. Is water an ionic or molecular compound?

6. From the above table, can you suggest any relationship between ΔT_b and molality?

7. Can you suggest an algebraic equation for the relationship in 6.

8. What is the value of the constant?

Experiment 2.

9. Identify the solute and the solvent.

   Solute _____ Solvent _____

10. Calculate moles of solute.

11. Calculate molality.

12. Calculate the elevation of boiling point.

13. Is Methanol an ionic or molecular compound?

* 14. Compare the result with Experiment 1. Do you see any similarity?

* 15. Do you think that the equation derived in Experiment 1 (Q 7) is applicable to ANY solute-solvent system?

Experiment 3.

16. Identify the solute and the solvent.

   Solute _____ Solvent _____

17. Calculate moles of solute.

18. Calculate molality.

19. Calculate the elevation of boiling point.

20. Is $AlBr_3$ an ionic or molecular compound?

* 21. Compare results of Experiment 1 & 2 with 3. Do they agree?

22. Are the solutes similar?

* 23. Do you still think the equation derived in Q 7 holds for all solutions?

* 24. All ionic compounds show deviations. Can you suggest an explanation?

25. The equation derived in Q 7 suggests that ΔT_b is proportional to molality (m). How do equal molal solutions of ionic and non-ionic compounds differ in species present in solution?

* 26. How does the vapor pressure of a solution compare with the vapor pressure of its pure solvent at the same temperature.

27. Answer question 26 with the knowledge that

(i) the boiling temperature of a solution is higher than that of pure solvent and

(ii) the boiling temperature is the temperature at which the vapor pressure of the solvent or the solution is equal to the atmospheric pressure.

* 28. What relationship do you expect between change in vapor pressure (ΔVP) and molality?

Opinion

Some students felt challenged and wanted more course material in this fashion. The majority of the students had difficulty in coping and needed help. A few did not like the method because this method makes them think. I feel the method is very slow. However, the students had an opportunity to participate actively in the learning process.

A laboratory experiment was designed to be tried by another group of students using ethylene glycol/water and naphthalene/benzene systems. This experiment was also done by Klaus Dickmann's class and was described in his report (Page 37.).

CHEMICAL EQUILIBRIUM

JAN JANMOHAMED CHEMISTRY 202-201-73

All students would have been introduced to chemical equilibrium in previous chemistry courses. Nevertheless, most students showed little or no understanding of the concept. Therefore, the following Generic Learning Situation was designed. Knowledge of algebra, chemical equations and concentration units is sufficient.

Objective: To find the relationship, if any, between the equilibrium concentrations of reactants and products of a chemical reaction.

$$H_2\ (g) + I_2\ (g) \rightleftharpoons 2\ HI\ (g)$$

The above reaction was investigated by heating sealed mixtures of hydrogen and Iodine or pure hydrogen iodide, in glass vessels. The vessels were then rapidly cooled to "freeze" the equilibrium. (Low temperatures preserved the concentrations of the reactants and products as they were at high temperature. Changes at low temperatures will be very slow). The contents of the vessel were then analysed.

a) The following results were obtained by heating hydrogen and iodine in sealed vessels at 698 K

$[H_2\ (g)]$ moles/l	$[I_2\ (g)]$ moles/l	$[HI\ (g)]$ moles/l
4.56×10^{-3}	0.74×10^{-3}	13.54×10^{-3}
3.56×10^{-3}	1.25×10^{-3}	15.59×10^{-3}
2.25×10^{-3}	2.34×10^{-3}	16.85×10^{-3}

(b) The following results were obtained by heating hydrogen iodide in sealed vessels at 698 K

$[H_2(g)]$ moles/l	$[I_2(g)]$ moles/l	$[HI(g)]$ moles/l
0.48×10^{-3}	0.48×10^{-3}	3.53×10^{-3}
0.50×10^{-3}	0.50×10^{-3}	3.66×10^{-3}
1.14×10^{-3}	1.14×10^{-3}	8.41×10^{-3}

Questions: Part A.

1. From which direction is the equilibrium approached.

* 2. Can you find a constant numerical relationship between the equilibrium concentrations of the reactants and products.

\# 3. Try: $\dfrac{[HI(g)]}{[H_2(g)][I_2(g)]}$ and $\dfrac{[HI(g)]^2}{[H_2(g)][I_2(g)]}$

_____ _____

_____ _____

_____ _____

4. Which one gives a better constant?

Part B.

5. From which direction is the equilibrium approached. Compare with 1.

6. Calculate the equilibrium constant as in 3.

$\dfrac{[HI(g)]}{[H_2(g)][I_2(g)]}$ and $\dfrac{[HI(g)]^2}{[H_2(g)][I_2(g)]}$

_____ _____

_____ _____

_____ _____

7. Which one gives the better constant?
8. Hence, write the constant in terms of reactants and products.
9. In this equation containing concentration terms in moles/l, the constant is represented by K_c and is called equilibrium constant.
10. By convention, we express the equilibrium constant as

$$K_c = \frac{[\text{Product A}]^a[\text{Product B}]^b}{[\text{Reactant X}]^x[\text{Reactant Y}]^y}$$

11. The above chemical reaction can also be represented as

$$1/2\ H_2\ (g) + 1/2\ I_2\ (g) \rightleftarrows HI\ (g)$$

Write the equation for K_c of this chemical equation.

12. Will the value of K_c in 7 and 11 be the same?
* 13. How are they related?
14. Why are the concentrations of hydrogen and Iodine the same in each of the first two columns of (b)?
15. Find the average value of K_c from the calculations that you have done on the results in (a) & (b) (Q 3 & 6)
* 16. If an equilibrium mixture of hydrogen, iodine and hydrogen iodide at 698^oK contains 0.50 mole hydrogen and 5.43 mole hydrogen iodide, how much iodine is present?
# 17. Why do you not need to know the volume of the system in order to obtain an answer in the above question?

Opinion: Having participated in one Generic Learning Situation on Colligative Properties, the students were better prepared for this and seemed to know what was expected of them.

Answer to Q 13 led to an interesting discussion on equilibrium constants.

Students had some difficulty - mainly due to poor algebra and arithmetics background

It went well with the students, and I was satisfied with the overall approach. I think the students' understanding of the K_{eq} concept was better.

SIMPLE HARMONIC MOTION

GERRY PORTNER PHYSICS 203-301-73

Prerequisite Concepts: The theory of simple harmonic motion and Taylor expansions.

Many text books include some problems which are extensions or interesting applications of the basic theory presented in the text. These problems are usually more difficult and if one assigns these to a class, not more than 10 to 15% of the students are able to solve them, the rest are left frustrated and probably feeling a little inadequate to the subject, as well as not having had the benefits of increased understanding.

The attached exercise tries to overcome this by leading the students through the new aspects of the theory in such a way that they have the opportunity of arriving at the results on their own, and if they don't, help is available. The students found this assignment instructive and interesting.

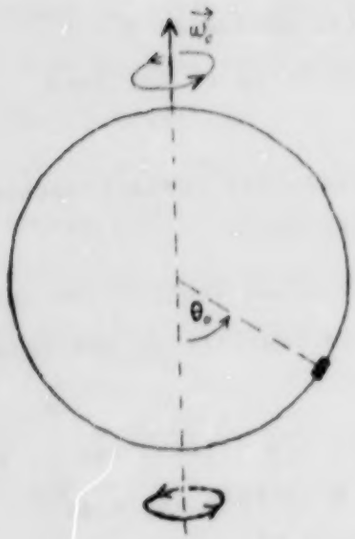
The following exercise is designed as a review of some of the basic ideas involved in simple harmonic motion and to introduce some new ideas. If you are unable to solve a particular part just continue to the next step, the solution will become apparent, at which point you can back and fill in the missing step. To obtain the greatest benefit from this, do not proceed until you have given some thought to each part. You should use a piece of paper to cover the page below the part you are working on, and keep the textbook handy, there are some references to it.

1. We have seen that SHM results from a force which has the form $\vec{F}$ =
2. A force of this type leads to a potential energy function of the form U =
3. The relation between $\vec{F}$ and U is _____
4. See text if you didn't get 3 (page 157)
5. There are some situations where the force on an object has exactly the form $\vec{F} = -k\vec{x}$, however, there are a very large variety of circumstances where the forces can be approximately put into this form. It is this latter type which will interest us here. These forces usually occur when a system in stable equilibrium is displaced slightly from its equilibrium position, and if the displacement is small enough the system will oscillate in SHM around its equilibrium position.
6. As a simple example of the above, consider a hoop placed in a vertical plane and a small bead placed on the hoop which can slide without friction. Draw all the forces acting on the bead. Then find the components of the forces acting tangential to the hoop.

7. Check your drawing with figure 15-10 on page 357.
8. Where is the equilibrium position of the bead?

_____

9. If the bead is displaced from equilibrium at $\theta = 0$, under what circumstances will the force on the bead have the form in 1. above.
10. Hint for (9) - compare the gravitational force component along the hoop with your answer to (1).
11. So up to this point we have established that if the bead is displaced by a small angle from equilibrium and released, SHM will result.
    Note - at 10^0 $\sin 10^0 = .17365 = \sin (.17453 \text{ rad.})$, so the difference between θ and $\sin\theta$ at this angle is only 0.5%.
12. Before moving on to the main point of this exercise let's complete the problem of the bead on the hoop. Write the differential equation for the bead and find the frequency and period of the oscillations, then solve the equation for the initial condition that the bead is released from rest at an angle of .15 rad.
13. Compare your answers to 12 with the solution on page 7 of these notes.
14. Now suppose the hoop begins to rotate with angular velocity around a vertical axis. (see diagram). Is it possible for the bead to be in equilibrium at an angle $\theta_0 > 0$? Explain briefly.



15. The answer to 14 is YES. One way to see this — is that when the hoop is rotating the hoop exerts a force on the bead whose vertical component can balance the gravitational force and the horizontal component provides the centripetal force to keep the bead moving in a circle. See a similar example of this on p. 118 of the text.
16. Let's call this type of equilibrium "dynamic equilibrium". The equilibrium position depends on the motion of the bead i.e. the angular frequency ω_0, of the hoop. What we want to examine here is the following; suppose the bead were displaced slightly from this new position of dynamic equilibrium, will it do simple harmonic motion around this position, and, if so, what is the frequency of this motion. Will it oscillate? Give some qualitative reasons for this.

17. The answer is that it does oscillate for small displacements from equilibrium. After working out the bead on the hoop in detail we will consider some more interesting examples such as the oscillation of a planet around its equilibrium orbit due to a small perturbation like a collision with a large meteorite, or a similar sort of motion on the atomic scale.

18. First let's find the new equilibrium angle θ_0. For our purposes, in what follows, it is convenient (though not necessary) to put ourselves in a reference frame rotating with the hoop. Use the diagram on p.3 for the following.

    a) The bead is moving in a circle with radius_____

    b) In the rotating frame there is a fictitious force called the _____. What is the direction of this force?

    c) The magnitude of this pseudo force is _____

    d) The gravitational force has a tangential component = _____

    e) Therefore the net force on the bead, tangent to the hoop is

    f) What is the condition for the bead to be in equilibrium under these forces

    g) What is the equilibrium angle?

    h) Compare your answers to this section with p. 7 of these notes. Make corrections where necessary.

19. Now at the equilibrium position the net tangential force on the bead is zero, but what does this force look like near the equilibrium, does it have the form which leads to simple harmonic motion. Well, try a Taylor expansion of the tangential force around the equilibrium position and keep only the first order terms in θ . i.e.
    i.e. $F(\theta_0 + \theta) = ?$
    Once you have found the force, write the differential equation of motion for small displacements from equilibrium and find the frequency of the oscillations.
20. The answer to 19 is on p. 8
21. Now try the following problem.
    Suppose a fairly large meteorite hit the earth and gave the earth sufficient velocity to displace it slightly from its equilibrium orbit, what would be the frequency of oscillations around the orbit?
    Assume a circular orbit for the earth and assume that the meteorite hits in a radial direction so that it doesn't change the component of velocity tangential to the orbit. In this case the earth's angular momentum won't change and therefore $L = mvr = mr^2\omega = \text{constant}$. Express the radial forces (gravitational and centrifugal) in terms of constant (including L) and r, then write the equation of motion for small displacements from the normal orbit r_0.

    Answer:

INTERFERENCE OF LIGHT FROM A LARGE NUMBER OF COHERENT SOURCES

GERRY PORTNER PHYSICS 203-301-73

Prerequisite Concepts: Addition of waves and the basic ideas of interference.

Situation:

This exercise was done in class with two students acting as the discussion leaders (at different times). These students solicited advice from the others on how to proceed with the calculations - the teacher saying as little as possible.

Method of Presentation:

The first part of the class consisted of a demonstration with only a description of what was being shown and no other comment from the teacher. The demonstration was shining the laser through two slits, then through about 1000 "slits", then through about 2000 "slits" (diffraction gratings). The intensity patterns were observed on the wall of the room. Then the attached sheets were used to calculate theoretically the observed intensities.

The first part of the exercise was in part a review; the second part was intended to use the ideas of the first part in order to calculate the intensity distribution for a diffraction grating. The mathematical techniques necessary to do this were taught earlier in the course.

Opinion:

The students enjoyed this class, and became much more involved than in the usual classes. It was necessary to hand out a complete exposition of the calculations at the next class, but this was to be expected because there were a lot of false starts and changes, etc., during the class. A better approach perhaps would have been to require the students to rewrite the calculations at home. Time did not permit the actual applications of the theory to measure the wavelength of the laser light, so this was done in a later lab period. When this was done, the students participated enthusiastically in making the measurements and doing the numerical calculations. In another semester of the same course this exercise was part of a take-home exam. The students were able to get clues on how to proceed if they had difficulties.

Interference of Light from a Large Number of Linear Sources:

We want to do the theoretical calculations which will predict the intensity patterns we have just observed with the laser and various slit arrangements.

1. The basic idea we use to derive this is:

2. Let's draw a clear diagram first. Start with two slits- we'll consider more later. Consider light waves travelling in a direction θ relative to the normal to the line joining the slits, and arriving at a screen a distance D from the slits where $D \gg d$. (d = slit separation).

3. When the light arrives at the screen in the direction θ, what is the phase difference between the waves from the two slits?

4. Under what conditions will the two waves be exactly in phase and exactly out of phase.

5. Write down the equations for the two waves — can you assume the amplitudes are the same — why?

6. Add the two waves to get the resultant wave.

7. What is the relationship between the intensity of the resultant wave and its amplitude?

8. Write the intensity at $\theta = 0$ $I(0)$
   and $\theta \neq 0$ $I(\theta)$

9. Then expressing $I(\theta)$ in terms of $I(0)$ we have

   $I(\theta) =$

10. Draw a rough graph of $I(\theta)$

11. Assuming the angle θ is small and D is large ($\gg$ d, as in the demonstration), calculate the separation between the positions of maximum or minimum intensity. (These are the same — why the equal spacing?)

12. Let's use this result to calculate the wavelength of the laser light. How should we do this?

13. Now let's use these same ideas to calculate the intensity of coherent light passing through a large number of closely spaced slits. This sort of arrangement is called a diffraction grating. Draw a diagram showing a few of the slits, and the light travelling at an angle θ.

14. What is the phase difference between the waves from adjacent slits, in the direction θ.

15. If the phase difference between the slit at one end and its adjacent slit is $\emptyset$, what is the phase difference between the end slit and the third slit, fourth slit, etc.

16. Write down the sum of all the waves from all the slits, in the direction θ.

17. To add up all these waves, let's try using complex numbers. Write the previous sum as a sum of complex numbers, then do the sum. (Hint — does it look like a familiar series?)

18. The previous sum is a complex number whose magnitude squared can be found by calculating zz^*. Carry out this calculation and express the intensity at angle θ in terms of $I(0)$.

19. Check that for $N = 2$ the result agrees with the two slit calculation.

20. For arbitrary N, in what directions will the intensity be a maximum?

21. Now let's use these results to measure the laser wavelength.

SINGLE SLIT DIFFRACTION

GERRY PORTNER PHYSICS 203-301-73

Prerequisite Concepts: Addition of waves, basic ideas about interference.

Situation: In-class exercise.

Method of Presentation:

This was presented in the same manner as the previous exercise on interference. A demonstration of single slit diffraction was presented using a laser and a variable slit; then some films on diffraction of water waves were shown. The teacher then conducted the theoretical discussnon and attempted to have the students indicate how to proceed with the calculations. A complete version of the calculation was distributed at the end of the class.

Teacher Opinion:

This method of presenta-tion elicited much more student involvement than usual, and did not take much more time than required by the usual lecture presentation.

Single Slit Diffraction:

1. In the film we have just seen, how does the wave pattern change as the size of the opening changes? Draw a few rough pictures.

2. This phenomenon is called diffraction.

3. Write down a statement of Huygen's principle.

4. Consider a slit of width a (where a is greater than the wavelength of the wave) and divide it into an infinite number of sources of circular waves, each source having a width dx. Draw a diagram. Then let's discuss qualitatively, when diffraction occurs.

5. Now, let's use the same technique that we used for the diffraction grating to calculate the intensity pattern for a single slit. Note that instead of summing the waves from N sources, each separated by a distance d, we have to integrate over an infinite number of sources separated by a distance dx. Do the calculation, repeating the same steps as in the N slit case.

RELEVANCY IN PHYSICS

GERRY PORTNER PHYSICS 203-101,102,301

Several problems were used in an attempt to place the simple theory in a more interesting context and to help students make the leap from theory to real applications of physics, a conceptual jump which usually is a surprise at the introductory level. There is a fairly widespread view on the part of students of physics that the material they are learning is merely a prelude to the "real thing" and that elementary material has very little validity in dealing with more complicated situations. This type of problem, hopefully, dispels this view. The following are a few examples:

1 Physics as Parable

Prerequisite Concepts: How light reflects from surfaces.

George Eliot, in her novel Middlemarch (Ch.27) makes the following observation —

> "An eminent philosopher among my friends, who can dignify even your ugly furniture by lifting it into the serene light of science, has shown me this pregnant little fact. Your pier-glass* or extensive surface of polished steel made to be rubbed by a housemaid, will be minutely and multitudionously scratched in all directions; but place now against it a lighted candle as a centre of illumination, and lo! the scratches will seem to arrange themselves in a fine series of concentric circles around that little sun. It is demonstrable that the scratches are going everywhere impartially, and it is only your candle which produces the flattering illusion of a concentric arrangement, its light falling with an exclusive optical selection. These things are a parable. The scratches are events, and the candle is the egoism of any person..."
>
> * mirror

Problem:

1. Verify, by experiment, the phenomenon which George Eliot is describing.
2. Explain the effect. Hint – think about how light reflects or is scattered from a scratch, and how the orientation of the scratch affects what will be observed.

2 A Problem on Automobile Collisions Physics 101,102

Prerequisite Concepts: Kinematics and dynamics, work and energy - at an introductory level.

We would like to examine some of the statements made in the article on car collision tests (New Scientist Jan.75) in the context of our studies of mechanics.

1. Assuming that the car's front end is effectively less still for a 60^{o} collision, (third papragraph), why does this reduce the deceleration felt by the passengers?
2. In paragraph five the claim is made that – human injury depends on change in velocity, and that structural deformation is proportional to the difference in the squares of the initial and final velocities. Assuming that the forces and accelerations are approximately constant during the collision, discuss the above statements with reference to the equations we have studied. How would time or distance over which the collision occurs afect human injury.

LIQUID-LIQUID SOLUTIONS AND MOLECULAR ATTRACTION

SUBBANNA VADLAMUDY CHEMISTRY 202-201-75

Objective:

To compare the magnitudes of inter and intra-molecular attraction with the help of the sign of ΔH mixing of a solvent (1) and a solute (1) that do not ionize to predict their behaviour.

Prerequisites:

Knowledge of heats of reactions, ΔG, reaction spontaniety potential energy and electrical attraction.

* 1. In the following table the sign of ΔH mix and ΔG mix for three types of solutions formed between two liquids A and B is given. Compare the attraction between A and B to that of average attraction of A to A and B to B, ie. A to B $\frac{\text{A to A + B to B}}{2}$. Use greater, smaller or equal in your comparison.

SOLUTION OF A AND B	SIGN OF ΔH mix	SIGN OF ΔG mix	A to B $\gtrless \frac{\text{A to A + B to B}}{2}$
TYPE I	POSITIVE	NEGATIVE	
TYPE II	0	NEGATIVE	
TYPE III	NEGATIVE	NEGATIVE	

\# 2. If you can not compare, consider that the mixing process is the net result of the following process:

$$-A--A- \longrightarrow 2-A- \qquad \Delta H_1$$

$$-B--B- \longrightarrow 2-B- \qquad \Delta H_2$$

$$2-A- + 2-B \longrightarrow 2\ -A--B- \qquad \Delta H_3$$

$$\Delta H \text{ mix} = \Delta H_1 + \Delta H_2 + \Delta H_3$$

3. If you still cannot answer, consider the following:

$$\oplus \quad \ominus \longrightarrow \oplus \quad \ominus \qquad \Delta H \text{ negative}$$

4. If you still can't answer, consider the following for type I solution:

   In the equation given in step (2)

   ΔH mix $= \Delta H_1 + \Delta H_2 + \Delta H_3$

   only ΔH_3 is negative.

5. In forming type II solution, energy neither was absorbed nor evolved, i.e. average energy required to break aA - -A and B -- B bond is equal to energy given out when a A - - B bond was formed.

* 6. If it is possible to observe a physical property of solutions I, II and III under similar conditions, predict which one behaves ideally, or show positive or negative deviations.

Opinion:

This Generic Learning Situation was used before starting liquid-liquid solution systems. This was the first time that the student had experience with Generic Learning Situations. After an initial shock (all thought this was a surprise test) they found to their suprise that the unit was designed to interrelate their knowledge of different areas of chemistry. Nobody was able to answer the first question without clues.

ELECTROLYSIS

SUBBANNA VADLAMUDY

CHEMISTRY 202-201-75

Objective:

To derive the Faraday's laws of electrolysis.

1. The process of electrolysis, in which a chemical compound is decomposed by an electric current, is used in electroplating of metals. Electroplating may be considered as a chemical reaction between positively charged ions and electrons as follows:

$$Na^{+} + e^{-} \rightarrow Na$$

$$Ag^{+} + e^{-} \rightarrow Ag$$

$$Cu^{+2} + 2e^{-} \rightarrow Cu$$

$$Au^{+3} + 3e^{-} \rightarrow Au$$

$$Fe^{+2} + 2e^{-} \rightarrow Fe$$

$$Fe^{+3} + 3e^{-} \rightarrow Fe$$

* 2. If we pass an electric current through a solution with proper arrangements, metal deposition takes place on a cathode. On what factors does the amount of metal deposited depend?

* 3. What type of relationship do you expect between the mass drposited (m) and the amount of charge (Q) passed through the solution?

* 4. What type of relationship do you expect between mass deposited (m) and atomic mass (w) if the same amount of charge is passed through solutions of different monovalent cations of the same strength?

5. What type of relationship do you expect between mass deposited (m) and valence (z) when the same amount of charge is passed through equimolar solutions of a cation with different charges?
6. Combine all the relationships in 3, 4 and 5 into one and write an algebraic equation relating m, Q, w and z.

Opinion:

With the knowledge that the students had already acquired so far in chemistry and other subjects, all were able to complete the situation satisfactorily. Some were able to recognize a certain resemblance to gas laws in the derivation.

INTERPRETATION OF GAY-LUSSAC'S LAW

SUBBANNA VADLAMUDY

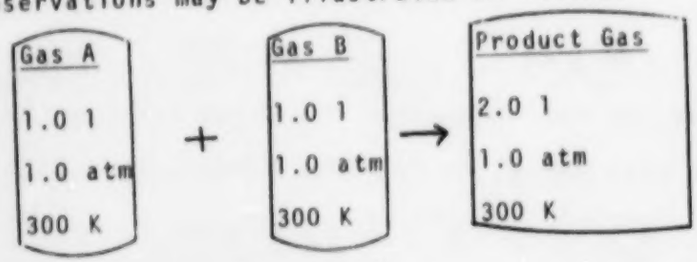
CHEMISTRY 202-111-73

Interpretation of Gay-Lussac's law of combining volumes, more commonly known as Avogadro's Hypothesis, offers an ideal opportunity to develop a Generic Learning Situation. A knowledge of laws of chemical combination, gas laws, postulates of kinetic theory of gases, and Dalton's atomic theory, is essential.

Objective:

To interpret Gay-Lussac's law of combining volumes.

Gay-Lussac's law of combining volumes states that when gases combine chemically, they do so in small whole number ratio of volumes at the same temperature and pressure. Gay-Lussac's observations may be illustrated as follows:



(Ratio of 1 :1 :2)

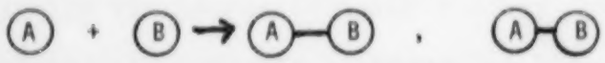
1. Assuming that all gases are made up of particles that are constantly in motion, colliding with the walls of the vessel, causing pressure, and that the atom is the smallest part of an element that enters into a chemical reaction, how does the number of particles of gas A, B and Product in the above illustration compare? (suggest a ratio).

2. Amadeo Avogadro reasoned that equal volumes of gases at the same temperature and pressure contain and equal number of particles. Thus the ratio of particles of A, B and Product is 1 : 1 : 2.

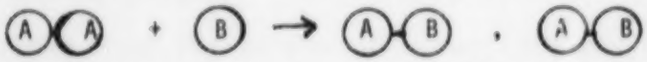
* 3. If two particles of Product compound are formed from every particle of A and B that have reacted, suggest a mechanism for such a process.

4. Which of the following processes is most probable? (Each circle represents an atom)

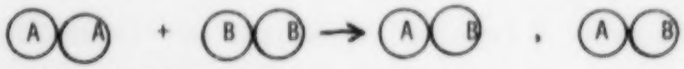
i) Particle of A & B contain one atom of each and the Product particle is formed from A and B.



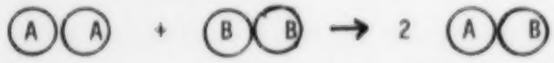
ii) Particle of A has two atoms (molecule), and particle of B has one atom, and particle of the Product is formed from A and B.



iii) Particles of A and B are molecules with two atoms each and the product molecule is formed from A and B.



written differently



* 5. Three volumes of gas X react with one volume of gas Y to give a gaseous product that occupies two volumes at the same temperature and pressure. How many atoms are present in the molecules of X, Y and the product gas?

Opinion:

Although students learned about Avogadro's Hypothesis before taking this course, most said that they were not aware of how and why the Avogadro's Hypothesis was formulated. The majority of the students had difficulty with the first step. Once they had recognized the Avogadro's Hypothesis, the subsequent steps proved to be easy to solve.

GENERIC LEARNING IN HUMAN BIOLOGY

ELEANORE VAN NORMAN BIOLOGY 101-921-75

In this situation, the 'Generic Learning' approach was used in a Human Biology course for a class of 30 first-year CEGEP students following a technology program in nursing to emphasize the application of the knowledge and skills they were developing. High School Chemistry and Physics were required for entrance into the nursing program, and as well, all but two of the students had taken High School Biology. Concurrently with the course in Human Biology, the students were required to take a course in Metabolic Biology. Thus, all of the students had a beginning background and vocabulary of chemistry and biology.

In the nursing program, the students receive just one year of Human Biology. As the volume of scientific and medical knowledge is increasing at a staggering rate, a major part of the course is the simple acquisition of knowledge. However, a major objective of the course is to develop an ability to apply and to use the knowledge acquired. The Generic Learning approach is used to pursue both of these objectives. The volume of information presented in such a course inhibits the practice of memorization as an effective method of acquiring knowledge. To be successful, it is mandatory that the student develop a means of organizing the information, and an ability to perceive the interrelation of the information acquired. In this course, wherever possible, new information is developed by reasoning from information and concepts learned previously. Students are encouraged, throughout the course, not to accept

Thus, much of the information presented in this course is developed step by step, by using questions to lead the student from the known to the unknown. As well, the limitations of the students' background and the time element involved makes it necessary to give some information passively. In the laboratory portion of the course, the students are required to apply their new knowledge to solve new problems. In order to answer the questions related to most of the laboratory experiments, the student must think and reason using the new concepts and information which she has learned. The students is required to move from learning into thinking.

Students who resist the insecurity of thinking and reasoning are able to overlook the generic presentation of new concepts and information presented in class, and are able to passively acquire the end piece of information. Thus, it is possible in the course for students to acquire and to store information passively. However, in the laboratory exercises, a simple regurgitation of knowledge is never asked. It is impossible for the student to achieve in the laboratory situation, without attaining some level of ability to use what she has learned.

The evaluation procedures in the course evaluate both the knowledge acquired and the ability to apply the knowledge to new situations. It is possible for a student to obtain a bare pass in the course (60 - 65%), simply as the result of acquiring and storing information. Beyond this, the student's grade is indicative of her success in applying her learning to master new situations.

Much of the class presentation of material uses the generic approach to learning, and many test questions are of a reasoning nature. A typical Generic Learning Situation is described below:

Generic Learning Situation:

The following learning situation was presented towards the end of the course in Human Biology. Printed sheets (91-95) were given to the students and overheads of the same diagrams and charts were used. The objectives given to the students for the learning situation were:

1. To compare the blood hydrostatic pressure in muscle, lung and glomerular capillaries with the special function of each structure.
2. To predict the glomerular hydrostatic pressure, given the other pressures involved in glomerular filtration.

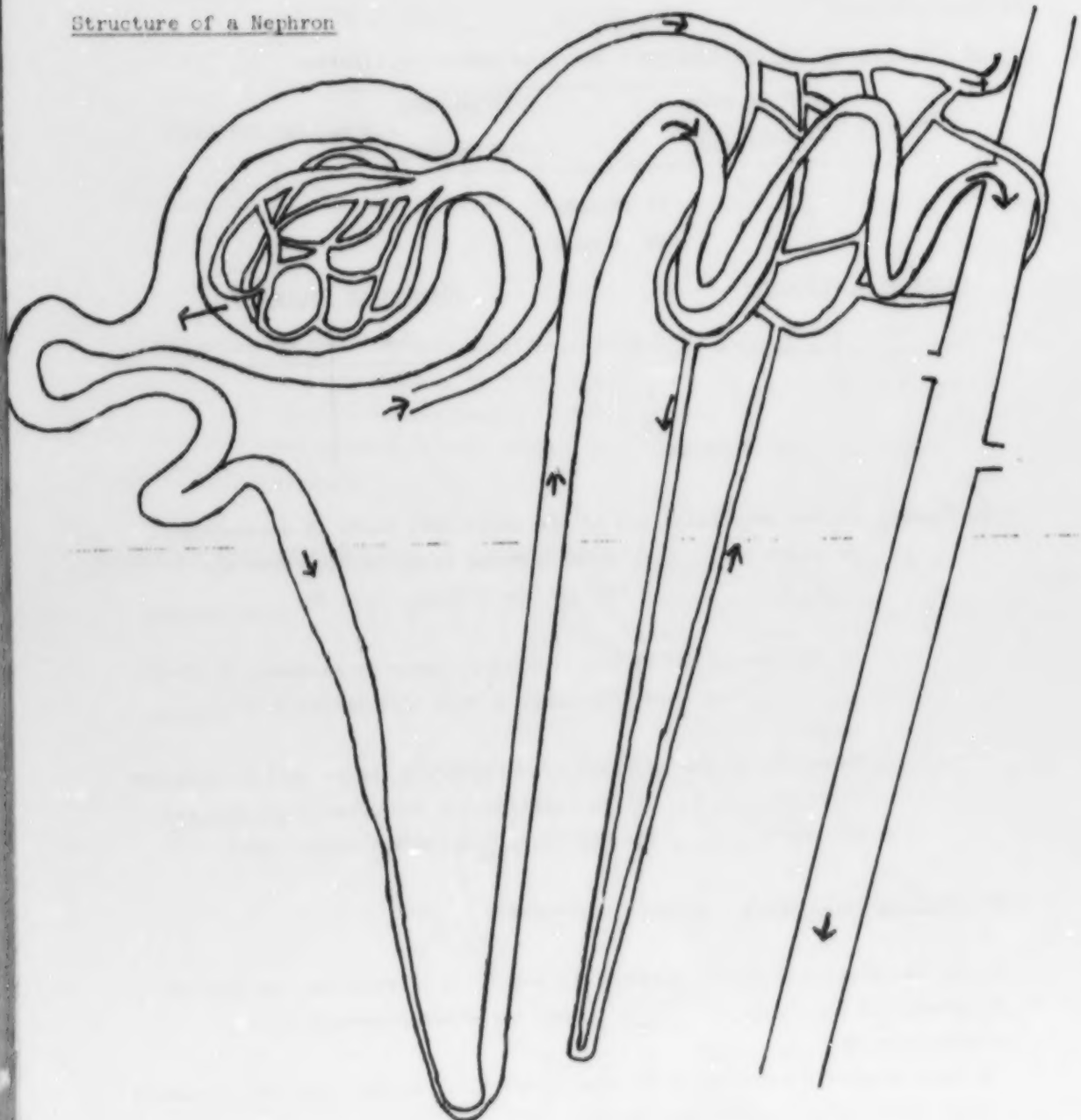
The situation was presented as follows:

1. New Information related to the renal circulatory structure and the structure of the nephron was presented passively. Students used their diagram of the "Structure of a Nephron" to note the information and terminology given. The general functions of the kidneys were given, as noted on the students' sheets,and the specific kidney function related to this situation were presented.

2. A Review of information and concepts previously learned and relevent to the present situation. This review was outlined on the sheets and the students were given ten minutes to follow it through on their own. During these ten minutes, the instructor gave individual attention to students. This review was then covered quickly in class by completing the same charts on the overhead.

3. The Generic Learning Situation, as outlined on the students' sheets, was given to the students for ten minutes to reason through on their own. Following this, the instructor, using the overhead diagram and charts, completed the presentation.

Structure of a Nephron



Function of the kidneys: to regulate the fluid and electrolyte balance and to regulate the acid-base balance of the body.

- specific function: in the present situation, you will note the ability of the kidneys to make excess water available for excretion.

Review

Capillary Dynamic:

a - In the majority of capillaries - eg. - in muscle capillaries

	BP 30 mmHg	BP 10 mmHg
arteriole →		→ venule
	COP 28 mmHg	COP 28 mmHg

TP -6 mmHg

COP 4 mmHg

Filtration Pressure	
Out	In

Absorption Pressure	
Out	In

Conclusion: At the arteriolar end of the capillary, there is a resultant pressure of _____ mm.Hg causing fluid to flow from the _____ through the membrane into the _____ _____.

At the venous end of the capillary, there is movement of fluid _____ the capillary under a resultant pressure of _____ mm.Hg.

Therefore in the majority of capillaries, there will be movement of fluid _____ of the capillary at the arteriolar end, and movement _____ the capillary towards the venule end.

b - In the lung capillaries - a special situation

Due to the short and highly distensible pulmonary circulation, peripheral resistance in the lungs is _____, and therefore pulmonary blood pressure is very _____.

The mean pulmonary arterial BP is approximately 13 mm.Hg., and the pulmonary venous pressure is only about 5 mm.Hg.

BP _____ mmHg BP _____ mmHg

arteriole ⟶ ⟶ venule

COP 28 mmHg COP 28 mmHg

TP - 0

COP - 0

Resultant Pressure

Out	In

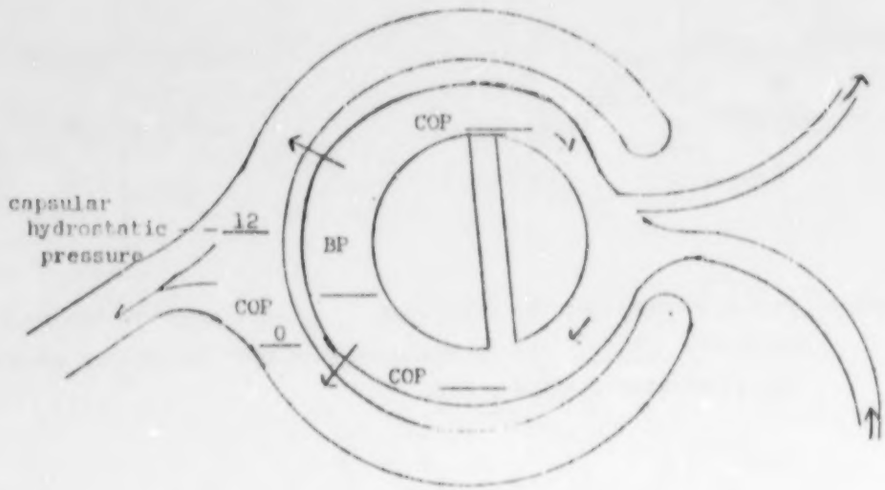
Resultant Pressure

Out	In

Conclusion: In the pulmonary capillaries, there is a resultant _____ward pressure tending to cause fluid to move _____ the capillaries over the entire length of the capillary.

The purpose of this special situation is to keep the lung alveoli _____.

GLOMERULAR CAPILLARY DYNAMICS - a special situation



- osmotic pressure of blood increases from the beginning to the end of the glomerular capillaries - from about 28 to 32 mm.Hg. Explain why!
- normally the plasma proteins are not filtered through the glomerular membrane, therefore the osmotic pressure in the capsule is 0 mm.Hg.
- fluid already filtered into the capsule creates a hydrostatic pressure of about 12 mm.Hg.

BP ? mmHg | BP ? mmHg

arteriole → | → arteriole

COP 28 mmHg | COP 32 mmHg

TF 12 mmHg

COP 0 mmHg

Glomerular Filtration Pressure

Resultant Pressure

Out	In
?	

Resultant Pressure

Out	In
?	

As one function of the kidneys is to filter and excrete excess body fluid, there must be a resultant _____ward pressure tending to cause fluid to move _____ the Bowman's capsule over the entire length of the glomerular capillary. Therefore the glomerular blood pressuremust be over _____ mm.Hg. in order to maintain a constant filtration.

The mean glomerular blood pressure is 65 mm.Hg. (with a gradient from 70 to 60 mm.Hg.)

Resultant Pressure

Out	In

Resultant Pressure

Out	In

Conclusion: In the glomerulus, the resultant _____ward pressure causes fluid to filter _____ the Bowman's capsule over the entire length of the glomerular capillary bed.

Comparison: of blood hydrostatic pressure with function

	Capillary Pressure Gradient	Function
Usual		
- in muscle capillaries	_____mmHg to _____mmHg	
Special Situations		
- in lung capillaries	_____mmHg to _____mmHg	
- in glomerular capillaries	_____mmHg to _____mmHg	

Opinion:

Students are divided in their opinions, and most express strong feelings whether for or against. Those students who enjoy reasoning are enthusiastic and find the Generic approach to learning exciting. They express a real feeling of achievement and self-satisfaction, and praise the course. Those who feel insecure in reasoning dislike the Generic approach and complain about the indirect presentation of new material, and complain about tests requiring reasoning rather than just a feed-back of information.

As the instructor, I find most students either especially like or dislike the Generic approach. On the whole, I find that the older students, especially those who have been out of school for a period and are returning, are more secure with a reasoning approach. They enjoy something they can "get their teeth into", and show great enjoyment and motivation. Many seem entranced by their discovery of how to learn. As some of these are students who do not obtain the best grades, my tentative conclusions are that the student's enjoyment of the Generic approach to learning does not depend solely on his or her ability to achieve, as much as on other factors.

Less secure and less mature students resist strenuously the demand made of them. They do not want to discover for themselves; they want to have a discovery presented to them. They do not want to read a reference for themselves and obtain the information; they want to be given notes that they can memorize. And above all, they do not want a thinking type of test; they want to be tested on the notes.

One of the aims of formal education is to teach a student how to learn, as a basis for the decades of self-learning ahead as an adult. Even though some students resist and resent being asked to think, I feel it is still useful to present as much class material as time allows using a Generic approach. Students who are unable to contribute in class may still discover the potential of thinking, and apply it in the security of the privacy of their own thoughts. However, for these students, the instructor must make a particular effort to contact them on an individual basis as they tend to feel too threatened to seek assistance on their own. It is vital that each student make some progress in reasoning, however small, to develop his or her confidence. The greater the time spent in using the Generic approach to learning, the greater must be the time allocated by the instructor for individual guidance.

As an overall opinion, I find that the Generic approach to learning is satisfying to the instructor and to some of the students, and is a reasonable goal to set for all of the students. All students will benefit from being able to move from acquiring and storing information to being able to apply this information to new problems.

GENERIC LEARNING IN GENERAL BIOLOGY II

SANFORD WITHERELL BIOLOGY 101-401-73

Students in 101-401 Biology would have generally completed 3 semesters of chemistry, 2 semesters of physics, 3 or more semesters of math and 1 semester of biology. They are reasonably well prepared to utilize analytical skills. An assumption, therefore, for the use of generic learning in an advanced-level CEGEP course would be that they can, in fact, use these skills. With this in mind, the information made available for each generic learning situation was so presented that there was the need of continuous integration of new material, a continuous building of knowledge to finally satisfy the original objective. Previously acquired biological knowledge was not a prerequisite.

The generic learning situations, as described here can be divided into four sequential steps, as follows:

1. Presentation on an overhead screen of an objective or derivation to be solved.
2. Sequential presentation on an overhead screen of three Facts.
3. Sequential presentation on an overhead screen of three groupings of Hints.
4. Presentation of solution.

The objective was presented on an overhead screen in large letters taking up most of the screen. The three facts were usually new material, but moderately challenging. They were presented on overhead screen and also given out on ditto sheets to each student. Students were asked to concentrate on the overhead screen. They could refer to their data sheets later if needed. The facts were presented one at a time, with the previous facts remaining on the screen.

Following the presentation of the facts, the students were asked to integrate the information and attempt to solve the objective. They were given approximately 5 minutes to relate this information, at which time they were asked to record their answer, if they had one, on paper. They

were warned not to communicate their results to neighbors.

The sequential presentation of hints followed, to either provide further information for solution or to corroborate the successful students' answers. The students were given several minutes after each of the hints, the particular time dependent on the rigorousness of the hint. The hints were shown in sequence on one overhead acetate sheet (but on a second screen from a second projector such that both facts and hints could be available simultaneously) by blocking off all but the hint being presented or previously presented. Thus, on completion of presentation, all three hints were projected together, in a similar fashion to facts presentation. The hints were given a title for interest development. For example, the hint section for DNA Structure was entitled "NOBEL NUDGES" in reference to nobel laureates Watson and Crick and their proposal of the DNA structure. The instructor introduced the hint section with Watson and Crick's involvement.

The instructor continuously insisted on logical argument based on the facts and hints in presentation of the answer. With the instructor's aid, an answer was arrived at. This was corroborated with overhead acetate sheets of the answer.

Opinion

1. There was initial difficulty in understanding the purpose of such a presentation. The 'lecture syndrome' held sway, until an appreciation of a challenge occurred.
2. Most students had a desire to take notes of both facts and hints. This of course is time consuming and detracts from total concentration on the analysis. This problem was partially alleviated by handing out mimeographed fact sheets, and could have been resolved with hint handouts as well.
3. I was somewhat disturbed to find how poorly many students performed. However, it is my feeling that with experience with Generic Learning situations, a student would develop a more analytical approach to problem solving.

4. This method is very time consuming. A lecture covering the same material would have taken half the time. Because time is a limiting factor (we are restricted to a course'plan d'etude'), this is most critical. I would recommend that because of these restrictions, and the lecture-based presentation, a Generic Learning Situation be offered only once every other class period.

Generic Learning Situation I

Objective:
Establishing the three-dimensional structure of DNA.

Fact I

DNA is composed of four kinds of nitrogenous bases as parts of units called nucleotides.

(a) Four nitrogenous bases:

(1) Pyrimidines:

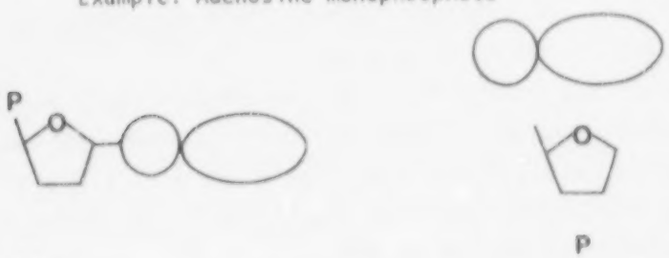
cytosine (C) and thymine (T)

(2) Purines:

adenine (A) and guanine (G)

(b) A deoxyribonucleotide (monophosphate)

Example: Adenosine monophosphate



= adenine

= deoxyribose

P = phosphate

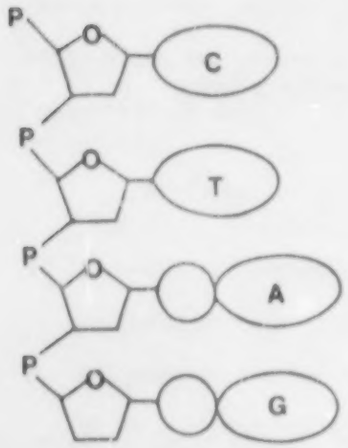
Fact II.

Nitrogenous base composition of DNA from two tissues (%)

Source	A	G	C	T	A/T	G/C
Calf Thymus	29	21	21	29	1.01	1.00
Salmon Sperm	30	21	20	29	1.02	1.02

Fact III.

A portion of a single strand of DNA.



= pyrimidines

= purines

= deoxyribose

P = phosphate

Structure of DNA

'Nobel Nudges'

Hint I:

X-ray analysis indicates:

(a) There is a constant 20 A diameter dimension of the molecule (10 A radius)

(b) The molecule is helical.

Hint II:

X-ray analysis indicates"

(a) There is a repeating structural 'major unit' every 34 A along the long axis of the molecule.

(b) There is a repeating structural 'minor unit' every 3.4 A along the long axis of the molecule.

Hint III.

(a) The DNA molecule is composed of two (2) strands.

(b) Hydrogen bonding is involved between a purine and a pyrimidine.

Presentation of Structure

1. An overhead acetate transparency showing:

   (a) a Double Helix of DNA
   (b) hydrogen bonding between complementary bases
   (c) structural dimensions.

Generic Learning Situation II

Objective:

Determining the process of DNA duplication.

Fact I.

A DNA molecule is composed of two strands (double-stranded molecule) held together by hydrogen bonds between complementary base pairs.

Fact II.

Nucleotides are available in the nucleus in the form of dATP, dGTP, dCTP and dTTP.

Fact III.

An enzyme, DNA polymerase, is present in the nucleus of all cells and catalyzes the polymerization of nucleotides into a new DNA molecule.

Old DNA must be present as a primer.

'Polymerization Pushes'

Hint I:

A 'new' DNA double-stranded molecule contains 50% 'old' nucleotides and 50% 'new' nucleotides.

Hint II.

A single 'parent' DNA strand serves as a template for the synthesis of a 'daughter' strand. Complementary base pairing is involved.

HINT III.

DNA polymerase 'unzips' the parent DNA molecule and uses each of the two parent strands as a template for two 'daughter' strands.

Presentation of DNA Duplication Process

1. Electron micrograph of E. coli DNA duplication on an overhead acetate transparency.
2. Diagrams of the sequence of steps in DNA duplication on an overhead acetate transparency.

The above was presented with a verbal analysis of the process based upon Facts and Hints.

The following concepts could also be presented in the above manner:

1. "How can DNA, through RNA, serve as a source of information for protein primary structure"? (concept of the Genetic Code)
2. The sequence of events in the process of translation.

CONCLUSIONS AND LAST WORDS

The objective of this project was to show that 'teaching students to learn how to think' can be incorporated into the pedagogy even at College level. The examples given in the foregoing section are proof that it can be done. The answer to the question whether the generic learning situations have increased the students' ability to think, is outside the scope of this work. For one thing, about 20% of a course was taught using Generic Learning Situations and the course lasted only fifteen weeks. Any gain in thinking abilities may be coincidental. However, student opinion on the use of Generic Learning Situations in teaching was gathered. Of those questioned, 92% have said 'yes' to having some Generic Learning sessions and some lectures in the future. 8% said 'no'. Most of those who said 'no' said that they don't like to be forced to think.

Although the concepts used for Generic Learning are cognitive in nature, the actual situations provided several opportunities for affective learning also. On occasion, some students felt inadequate. This led to a hostile reaction in some and a sense of helplessness in others. A word of caution to those who want to use Generic Learning Situations in their teaching. Avoid comments like "it is easy", (sure it is easy if you know the answer), "think", "it is a stupid answer', etc. These could cause negative reactions in some. Be prepared to accept the unexpected.

Understandably, Generic Learning Situations take more time to get a concept across. As can be seen from the examples, the type of learning, 'Generic Learning", that they foster is

different. If one believes that this type of learning is equally important then the necessary time can be found within the pedagogical and curricular constraints. Certain suitable parts of the course could be assigned for self-study to save some lecture time. (Some of us are planning to incorporate Generic Learning Situations into a "Personalised System of Instruction".) In this experiment some teachers were able to do more than 20% of the course using Generic Learning Situations while others did less. The DAASAN approach calls for a change in the attitude of those who think that

1. The students learn in the classroom only.
2. The educational process is the attainment of specific behavioral objectives enunciated before the act of learning takes place,
3. and, the students don't know how to think and don't want to think.

Perhaps, the student should change some of his expectations also. Alas! as Skinner would say, "Anticipation is a conditioned reaction". If we place the student in a situation that forces him to think it is very likely that he will learn to think. The key is to prepare situations with multilevel concepts, or deal with the individual's problems as they arise. Generic Learning Situations are individualised in every sense. They are restricted only by the creative abilities and desire of the teacher to adapt to any situation or student. Therefore, our examples of Generic Learning Situations should not be looked upon as recipes to be followed. We hope that the techniques that we have used serve as models which are highly susceptible to change to suit the individual needs of the student.

APPENDIX I

Course Descriptions

BIOLOGY - 101-301-73

General Biology I

A required course for students in Pre-University Health and Pure and Applied Science and a possible option for Arts students.

Designed to provide students with a basic understanding of the great diversity of living forms and how they have evolved with time. Emphasis is on the interaction of environment and life showing how adaptation tu changing conditions in the past has prepared the way for life forms of today. To help understand these topics a study of modern and classical genetics is also included. Laboratory sessions complement the lecture material and are an integral part of the course.

General Biology II

101-401-73 Prerequisites: 101-301-73 General Biology I

202-201-73 General Chemistry

A required course for students in Pre-University Health Science, strongly recommended for Pre-University Pure and Applied Science students planning to enter Biological Sciences at University. An introduction to cell chemistry, cell structure and function and the regulation of cell activities in plants and animals. Multicellular organization and development. Regulation at the level of the whole organism: hormonal (plant and animal and neurological control. Laboratory exercises will include use of various experimental techniques and observation of representative plants and animals.

Human Biology I

101-921-75 Prerequisite:High School Chemistry

A required course for Radiography, Medical Laboratory and three-year Nursing students, and for Arts students planning to enter Psychology. Possible science elective for Arts students. An introduction to basic biological principles stressing the chemistry of life processes with particular reference to man. The course emphasizes cellular function, the nervous and endocrine control mechanisms which regulate the cellular environment. The laboratory exercises and designed to complement the theory discussed in class.

CHEMISTRY

General Chemistry I

202-101-73 Prerequisite: 202-111-73, or Chemistry 552, or permission of department.

Required for all students in Pre-University Science and Chemical Technology. Classical Atomic Theory; Review of Stoichiometry;Modern Atomic Theory;Quantum Theory and Atomic Structure;The Periodic Table, Chemical Bonds; Ionic and Covalent;Bond Polarity;Hydrogen-bonds;Metallic Bonding; Van der Waals Forces, Solids, Liquids, Gases; Phase Changes.

Introduction to College Chemistry

202-111-73 Prerequisite: 202-001-73, or High School Chemistry 512, 452 or equivalent.

Required for all students in Pre-University Science who do not have "Chemistry Study" (552). Matter and Energy; Atoms and Molecules, Atomic Theory;Chemical Reactions, Stoichiometry;The Gas Phase and Chemical Reactions; Solutions and Chemical Reactions; Energy and Chemical Reactions; Ions, the Electrical Nature of Matter; The Structure of the Atom and Chemical Bonding. Other topics may be included.

General Chemistry II

202-201-75 Prerequisite: 202-111-73 or equivalent, or permission of department.

Previous courses in Physics and Calculus desirable. Required for all students in Pre-University Science, Chemical Technology and Medical Laboratory Technology. Solution; Chemical Equilibrium; Ionic Equilibria; Energy and Chemical Equilibrium; Chemical Kinetics; Electrochemistry; Electrolysis; Redox reactions: Acids and Bases, pH: Buffer Solutions; Titrations.

MATHEMATICS

Introduction to Applied Mathematics A

201-101-73 Prerequisite: Functions 522 or equivalent

Choice of the following topics: Game theory, Graph theory, Combination analysis and introduction to probability, Boolean Algebra, Logic. Other topics may be selected being mindful of the general objectives as well as the specific objectives of the course. The number of topics taught will vary according to the needs of the students. However, normally 2 to 4 topics will be taught, except for special cases.

Statistics

201-337-73 Prerequisite: Functions 522/532 or equivalent

Descriptive statistics, binomial distribution (tests of hypothesis, sign test), normal distri ution (poisson distribution, central limit theorem, "t" distribution, estimation of population parameters), F-distribution, simple correlation and regression.

PHYSICS

Mechanics

203-102-74 Prerequisite: High School Physics (512,432, 452) or 203-111-73 and Functions (522,532) or equivalent

Contents: 1. Mathematical Review. Basic Algebra, Geometry and Trigonometry. 2. Slide Rule;Graphs; Statistical methods; Approximation Methods; Nature and estimation of Errors. 3. Vector Algebra. 4. Kinematics: Motion in one and two dimensions, freely falling bodies, projectile motion, uniform circular motion. 5. Dynamics: Newton's Laws, force, gravitation, conservation principles, frictional forces, inclined plane. 6. Rotational Motion: Kinematics and Dynamics, torque and angular momentum, moment of inertia. 7. Statics: Study of equilibrium conditions.

Mechanics

203-101-74 Prerequisite: 203-111-74 or 203-111-73 (special version) or 203-102-72 or PSSC physics (552,522)

Co-requisite: Mathematics 103 (we strongly recommend that the student actually complete Mathematics 103 before registering in this course.

Before taking this course it is desirable that a student have taken or be taking Mathematics 105 (Vectors). Contents: 1. Kinematics: Motion of particles in one and two dimensions, relative motion, freely falling bodies and projectile motion, uniform circular motion. 2. Dynamics: Newton's laws, gravitation, work, energy and power, conservative systems and frictional forces, collisions and cross-sections. 3. Rotational motion: kinematics and dynamics, torque and angular momentun, moment of inertia. 4. Statics: equilibrium of rigid bodies, centre of gravity. 5. Simple harmonic motion: basic principles, relation to uniform circular motion. 6. Theory of special relativity: historical background, Galilean relativity; Lorentz contraction and time dilatation, transformation laws between inertial frames, Einstein's addition theorem, rest mass, equivalence of mass and energy.

Electricity and Magnetism

203-201-74 Prerequisite: 203-101--4 and Math 103

Co-requisite: Math 203 (again we strongly urge the student to actually complete Math 203 before registering in this course.)

Contents: 1. Electrostatics: Coulomb's law, electric field and electrostatic potential, calculation of field and potentials for discrete and continuous charge distributors, Gauss' law, lines of force and equipotentials, electric dipples. 2. Dielectrics and capacitors: polarisation in material media in presence of electric fields. 3. Director current EMF, linear and non-linear circuit elements, Ohm's law, Joule's law and Kirchoff's law, circuit analysis, electrical energy and power, Wheatstone's Bridge and potentiometer. 4. Magnetic Field: Lines of induction, vectors B and H, Ampere's law and Biot-Savart's law, 5. Electro-magnetism: Magnetic forces on currents and moving charges, torques on current loops, equivalence of closed current loops and magnetic dipoles, Hall effect, cyclic accelerators. 6. Electromagnetic Induction Magnetic flux, Faraday's laws, time-varying magnetic fields, betatron, self and mutual inductances. 7. Transient phenomena: nergy densities of electric and magnetic fields, energies stored in capacitors and inductors. 8. Alternating current: Impedences, use of complex numbers in solving A.C. circuits, L-C-R and parallel circuits, tuning and resonance.

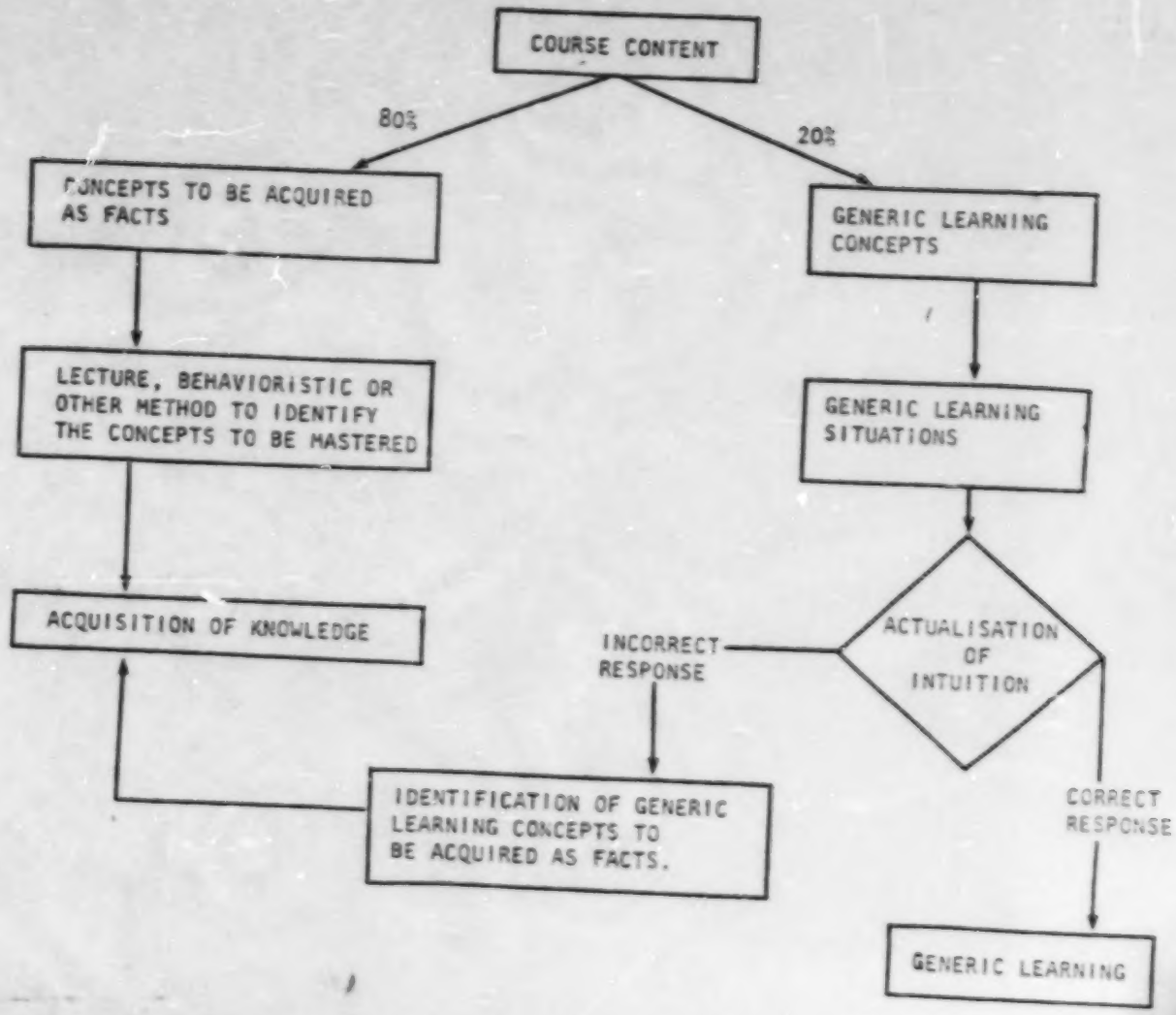
Waves and Modern Physics

203-301-74 Prerequisite: 203-201-74 and Math 203

Contents:1. Mathematical Review: Complex numbers, Taylor's expansion, second order differential equations with constant coefficients. 2. Oscillatory motion: simple harmonic motion, damping and effects of damping, forced vibration and resonance, energy and phase consideration, physical examples, combination of SHMs. 3. Mechanical Waves: longitudinal and transverse waves, general wave equation and its solutions, velocity of sound waves in a solid and in a gas, transverse waves in a string, interference of waves, stationary and progressive waves, beats, non-relativistic Doppler effect, phase velocity 4. Light waves: connection with electromagnetic waves, interference, diffraction (Fraunhofer and Fresnel), polarisation and optical activity. 5. Nature and propagation of light:Huygen's principle, correlation between particle properties and wave properties of light, velocity of light, relativistic Doppler effect. 6. Modern Physics old quantum theory, Planck's law, Wein's law Bohr's theory, De Broglie's theory, Davisson and Germer's experiment, photoelectric effect, Compton effect, structure of nucleus, radioactivity, elementary particles, fission and fusion, Schrodinger's equation and interpretation of wave function, uncertainty principle.

DIVISION OF COURSE CONTENT

CONCEPTS

METHODOLOGY

TERMINAL BEHAVIOR